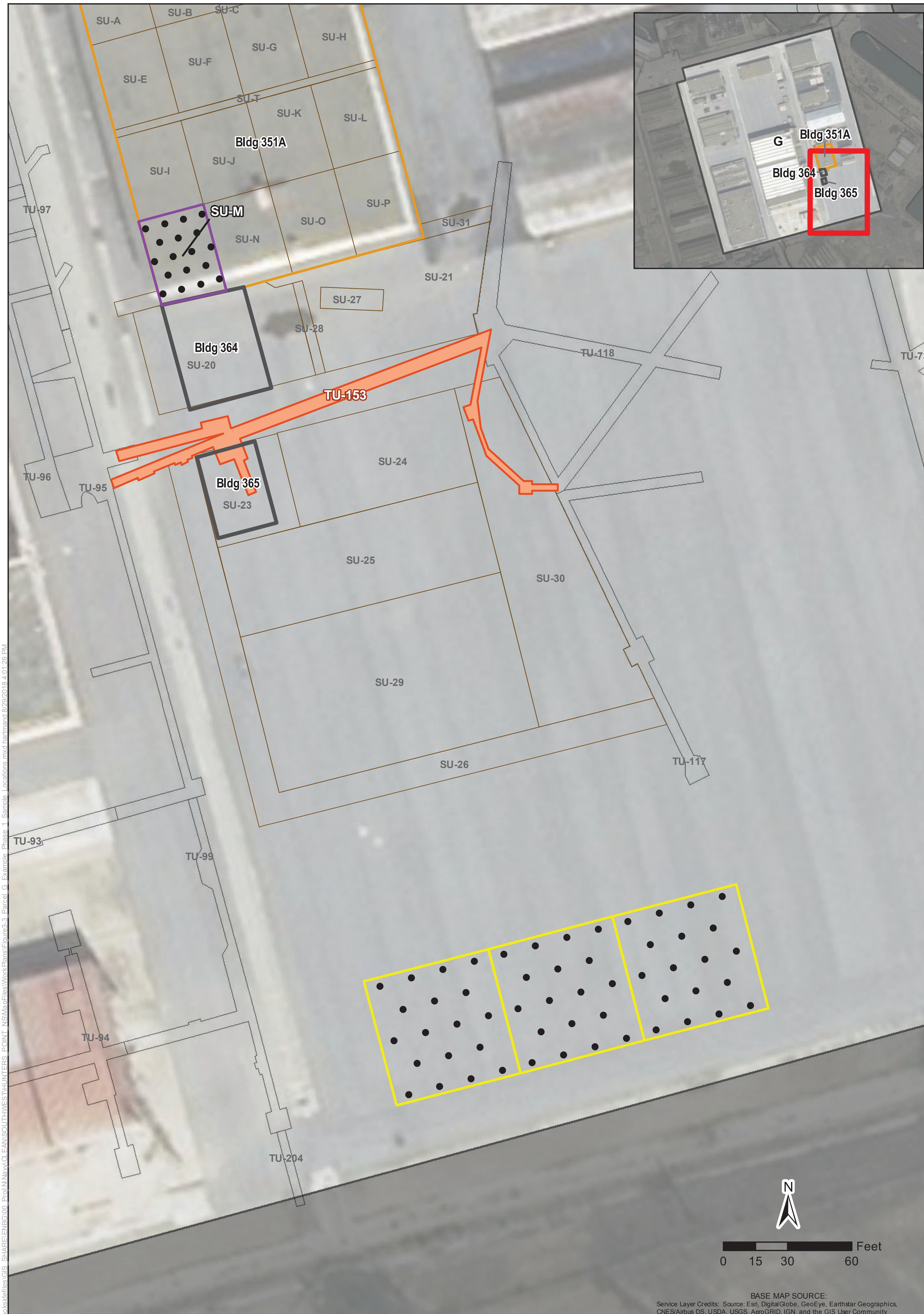


Legend:

- Systematic Sample Location
- SU-M
- TU-153
- RSY Pad
- Demolished Impacted Buildings
- Impacted Buildings
- Survey Units
- Trench Units

Figure 17-1
Example Soil Sample Locations for Phase 1 Trench Unit and a Survey Unit
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Legend:

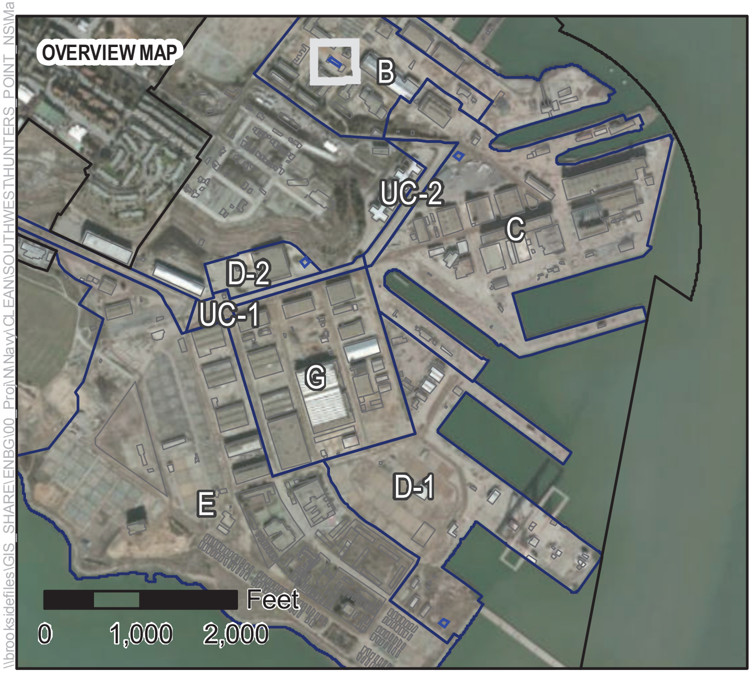
- Core Locations Inside TU
- Core Locations Inside TU Buffer
- TU-93
- TU-93 Buffer (6 Inches)
- Trench Units

N

0 10 20 40 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-2
Example Phase 2 Trench Unit Soil Sample Locations
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend:

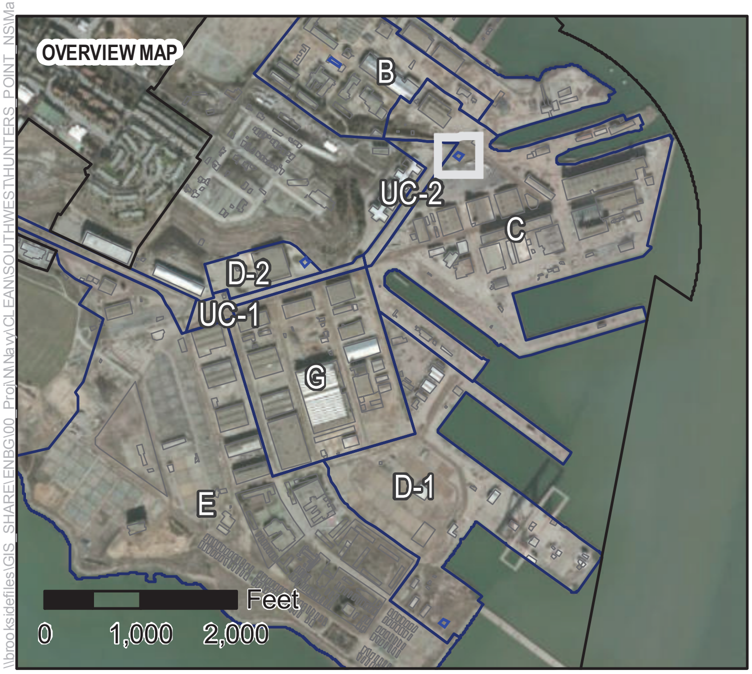
- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-3
HPNS Reference Background Area RBA-1
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\N\Navy\CLEAN\SOUTHWEST\HUNTERS_POINT_NS\MapFiles\RDEF_ReportMaps\BackgroundRefAreas\Hunters_Point_Background_points.mxd hartmand 9/26/2018 4:01:50 PM



Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-4
HPNS Reference Background Area RBA-2
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

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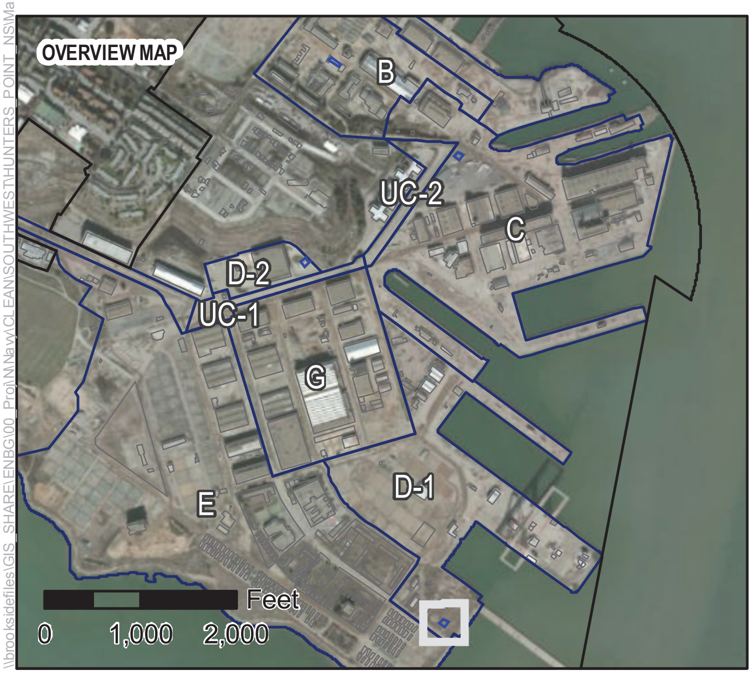

Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-5
HPNS Reference Background Area RBA-3
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

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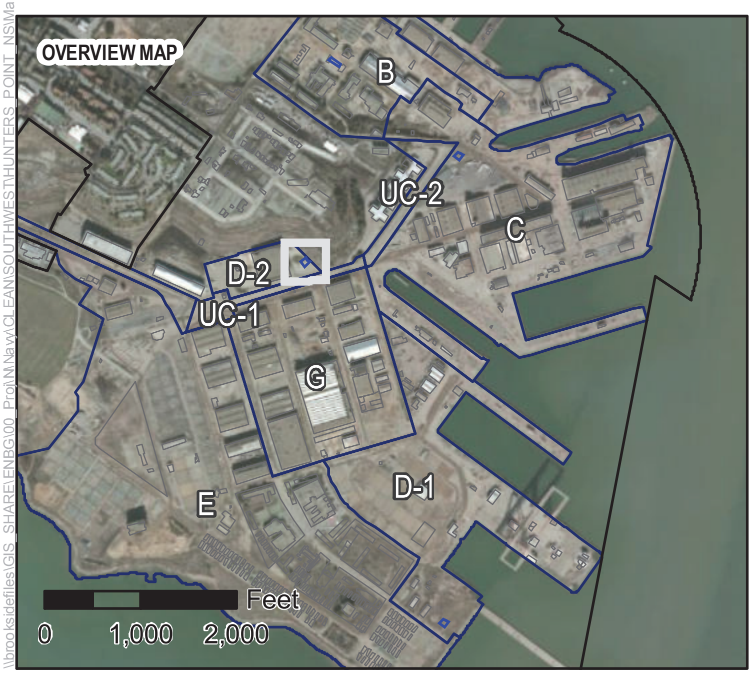


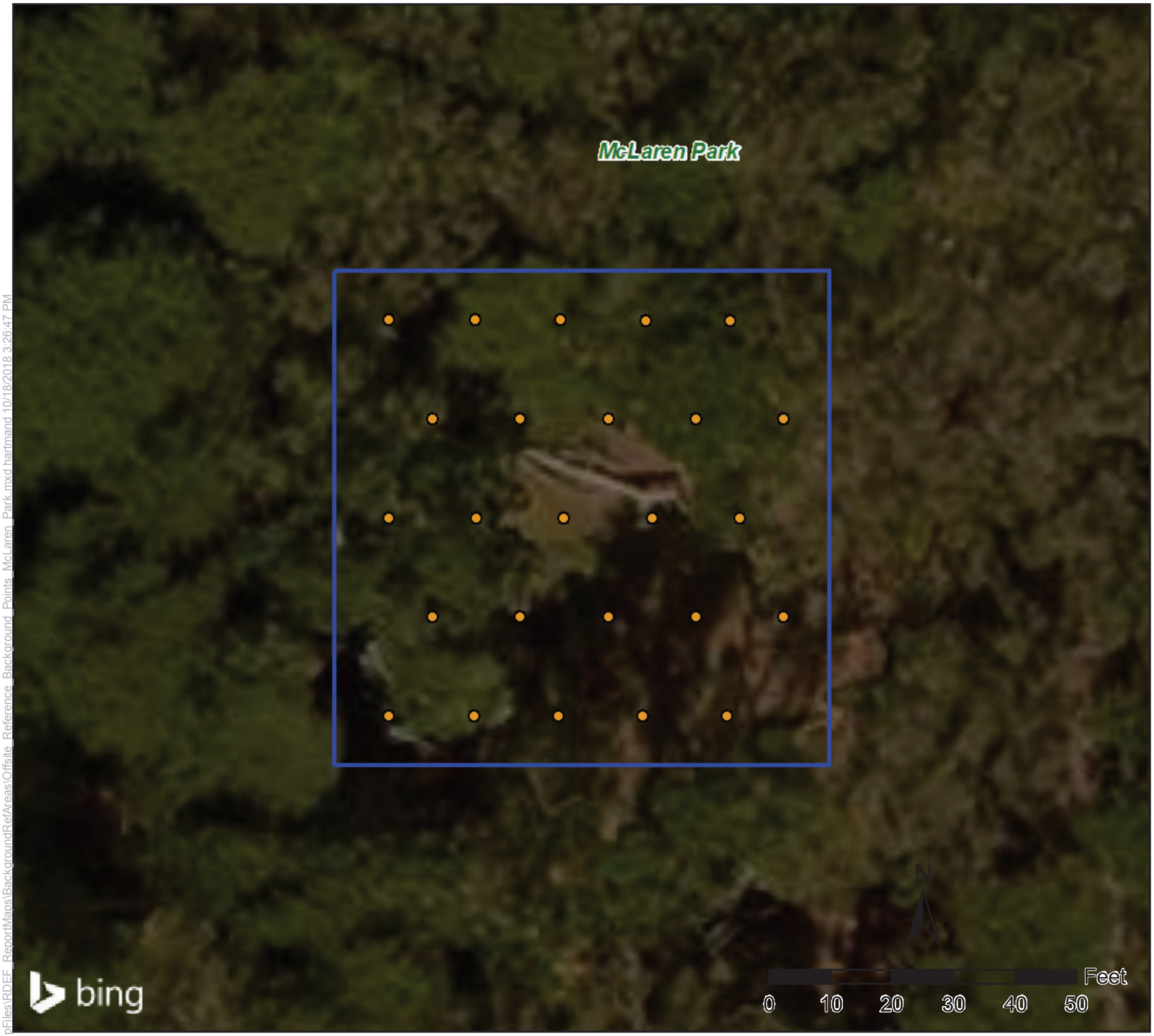
Legend:

- Surface Sample Location
- Surface and Subsurface Sample Location
- Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

COORDINATE SYSTEM:
NAD 1983 StatePlane California III FIPS 0403 Feet

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 17-6
HPNS Reference Background Area RBA-4
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend:

- Surface and Subsurface Sample Location
- Reference Background Area*
- Park

* NOTE: The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

COORDINATE SYSTEM: NAD 1983 StatePlane California III FIPS 0403 Feet

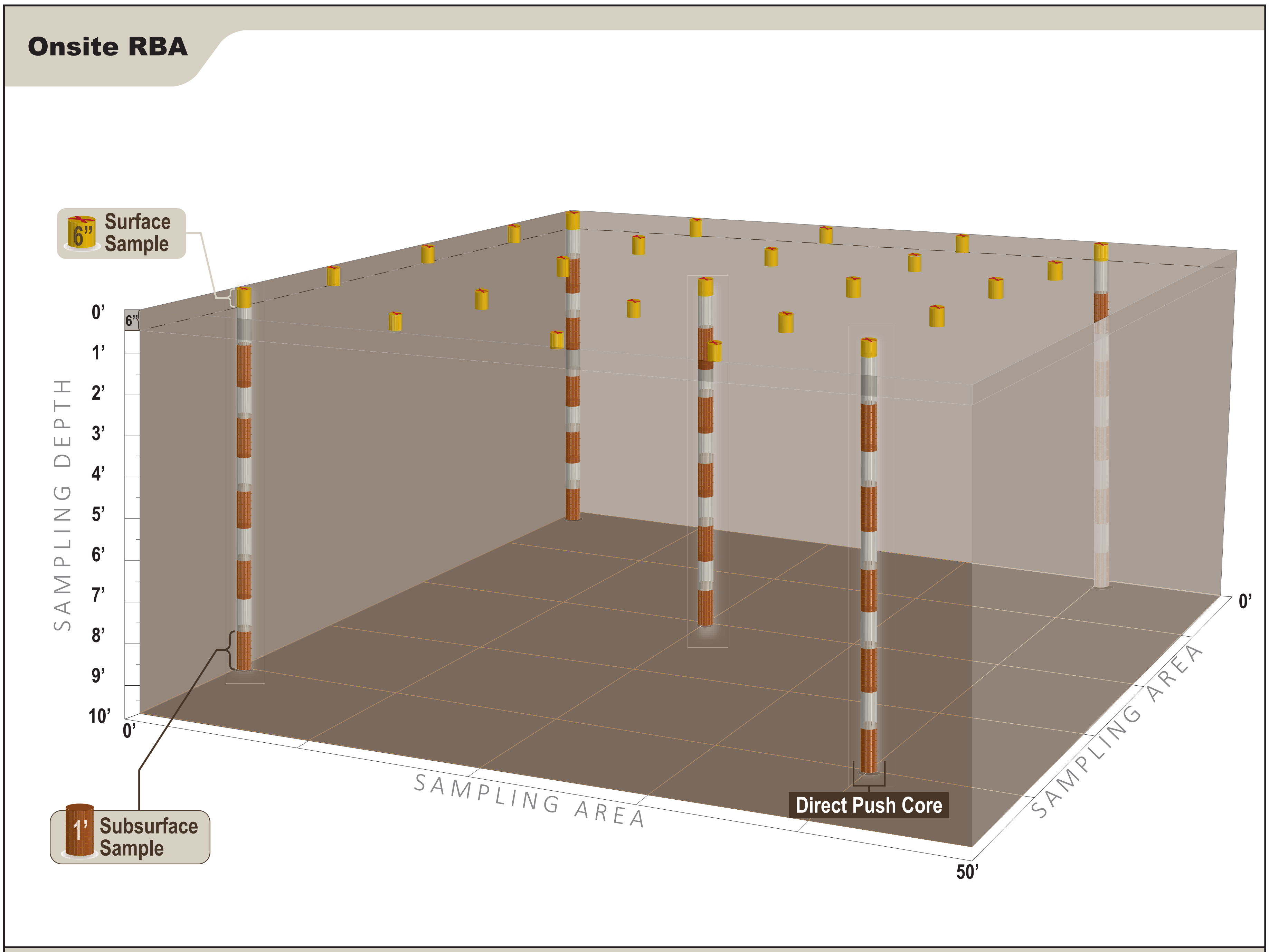
BASE MAP SOURCE: Service Layer Credits: © 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS

Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

Figure 17-7
McLaren Park Reference Background Area
RBA-McLaren
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

CH2M-9000-FZ12-0013, JUNE 2019

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\N\Navy\CLEAN\SOUTHWEST\HUNTERS_POINT_NS\MapFiles\RDEF_ReportMaps\BackgroundRefAreas\Offsite_Reference_Background_Points_McLaren_Park.mxd hartmand 10/18/2018 3:26:47 PM



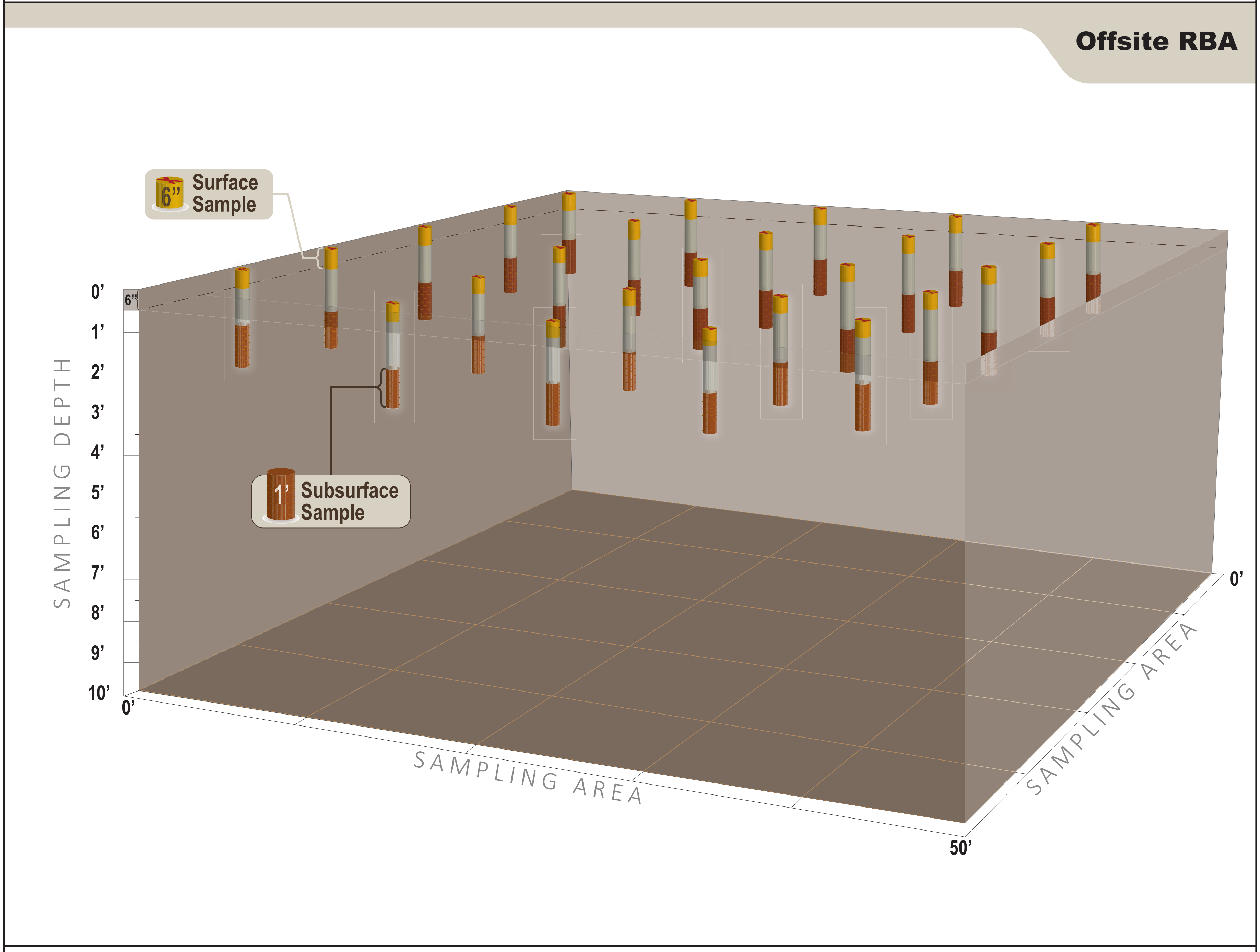
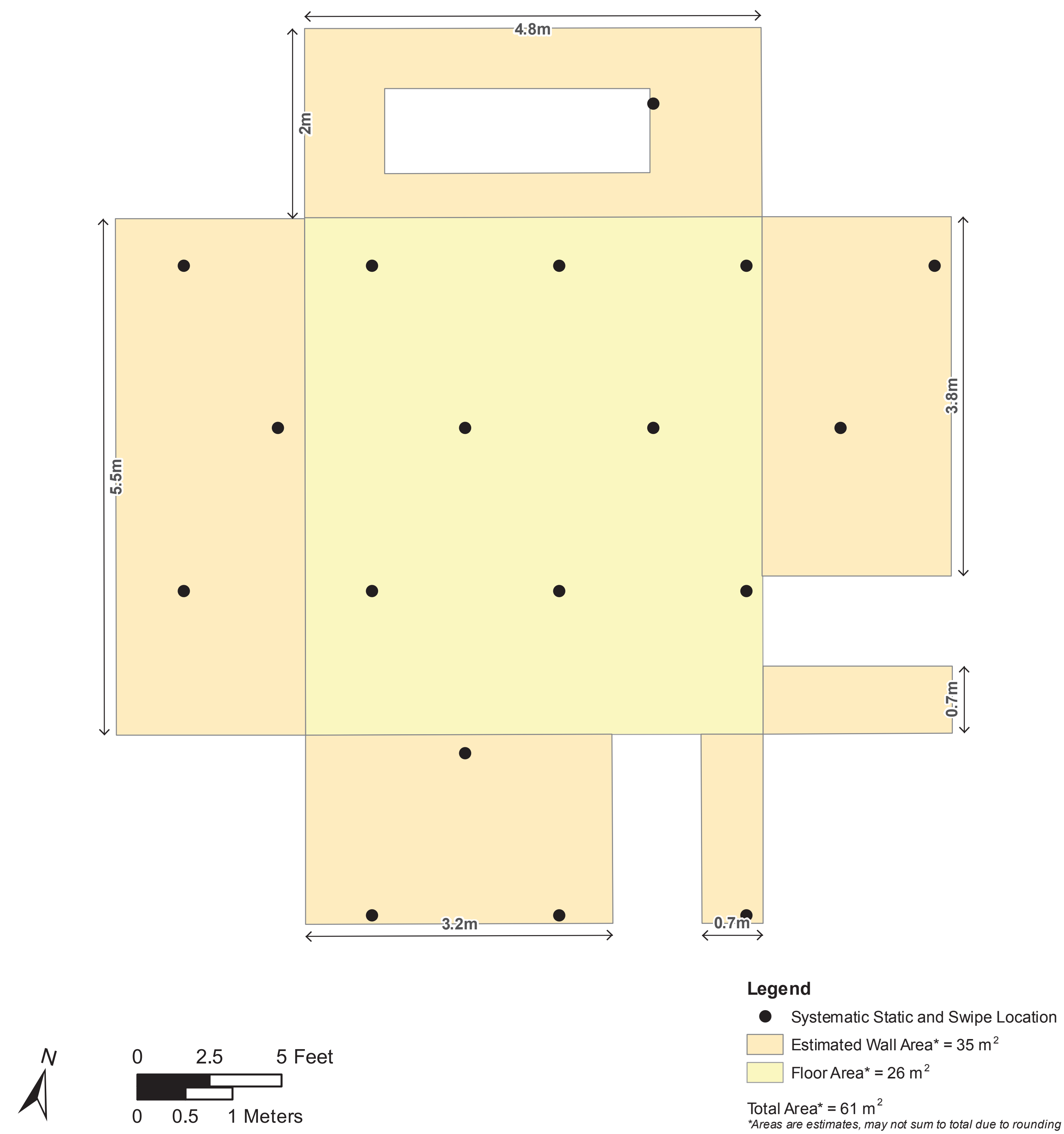
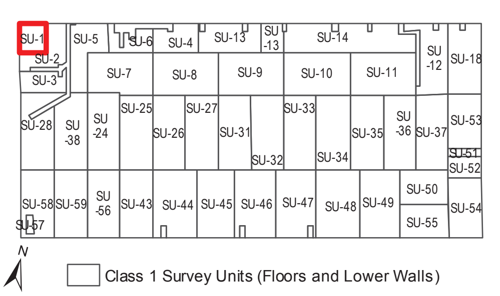


Figure 17-8
Example Surface and Subsurface Sample Locations
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, CA

JETT TBD

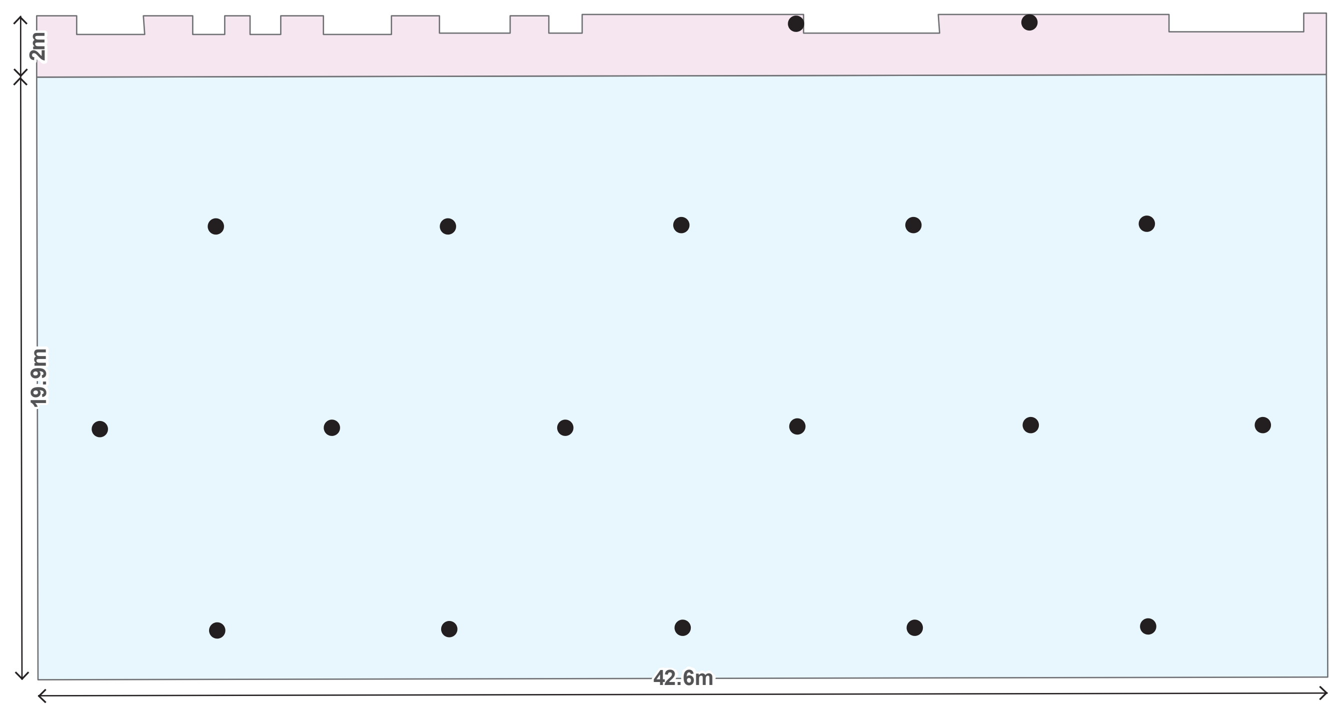




Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007) and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

Figure 17-9
Example Building Class 1
Survey Unit and Sample Locations
(Building 366 Survey Unit 1)
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California



N
0 25 Feet
0 5 Meters

Legend

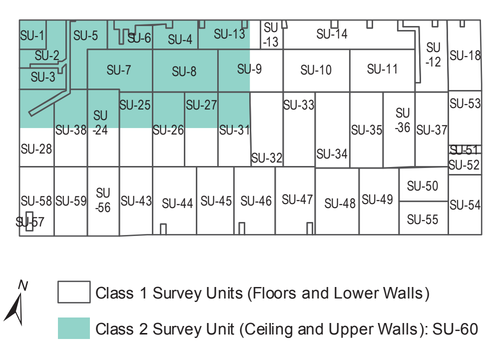
● Systematic Static and Swipe Location

Estimated Ceiling Area* = 850 m ^{2}

Estimated Upper Wall Area* = 74 m ^{2}

Total Estimated Area* = 923 m^2

**Areas are estimates, may not sum to total due to rounding.*



Class 1 Survey Units (Floors and Lower Walls)

Class 2 Survey Unit (Ceiling and Upper Walls): SU-60

Note: Survey Unit and Floor Plan data are based on available documentation, and may not reflect current site conditions. Updated site maps will be prepared as part of the building surveys.

Data source: Department of the Navy Base Realignment and Closure report, "Final Final Status Survey Results, December 30, 2009, DCN: ECSD-5713-0072-0043" prepared by TetraTech, CTO No. 0072. Multiple drawings were georeferenced and digitized in GIS. Survey Unit data are based on figures 1-2 (2007), 2-7 (2008), and 4-2 (2008). Trench Units from CH2M Phase 1 report. Dimensions are approximate.

Figure 17-10
Example Building Class 2
Survey Unit and Sample Locations
(Building 366 Survey Unit 60)
Parcel G Sampling and Analysis Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Attachment 1
Project Scoping Meeting Minutes and Responses to Comments

MEETING SUMMARY

Hunters Point Naval Shipyard Scoping Meeting San Francisco, California

ATTENDEES:

Derek Robinson, Navy
Pat Brooks, Navy
Bill Franklin, Navy
Danielle Janda, Navy
Lily Lee, EPA RPM
David Yogi, EPA
Jackie Lane, EPA
Tamsen Drew, OCII (Office of Community Investment and Infrastructure)
Amy Brownell, SFDPH
Scott Hay, Cabrera Services
Janet Naito, DTSC
Nina Bacey, DTSC
Sheetal Singh, CDPH
Jeff Wong, CDPH
Tina Low, Water Board
Kellie Koenig, CH2M
Robert Kirkbright, CH2M
Adam Engel, CH2M

On Phone:

Matt Slack, RASO
Zach Edward, RASO
LCDR Soric, RASO
Dr. Steve Doremus, RASO
Jana Dawson, Tech Law
Mark Luckhardt, Five Point
Lindsay Land, EPA
Carla Brazen

DATE: December 13, 2016

PROJECT: Navy CLEAN 9000, CTO-FZ12

Objectives

The objectives of the meeting were to introduce team members, discuss radiological data evaluation and community outreach activities, and gain feedback, input, and buy-in from stakeholders.

Introduction

A presentation and schedule were provided to all invitees prior to the meeting.

Derek Robinson from the BRAC PMO kicked off the meeting by thanking everyone for attending, and stated how important this project is for the Navy, BRAC, the City of San Francisco, Regulatory Agencies, and developers. He stated the urgency of this effort and the requirement to get it done right the first time. Lily Lee mentioned the EPA will be sending a letter outlining recommended actions. Derek also said that this venue is a good place for everyone to meet face to face. Pat Brooks and CH2M will be presenting the strategy and scope of the planned efforts which hopefully can draw to a close any unanswered questions

Introductions were made.

The Tiger Team points of contact were identified:

NAVY - Pat Brooks, Derek Robinson, Danielle Janda, Zachary Edwards, and Matthew Slack

DTSC - Janet Niato and Nina Bacey

EPA - John Chestnut and Lily Lee

CDPH - Sheetal Singh and Jeff Wong

Water Board – Tina Low

City of San Francisco - Tamsen Drew (OCII) and Amy Brownell (SFDPH)

Bob Kirkbright began the presentation with a brief discussion of the team CH2M has assembled, pointing out the challenge in finding experts for the team that have not been involved with Tetra Tech or its affiliates and subcontractors to avoid any possible perception of a conflict of interest. The assembled team consists of a consortium of experienced experts from CH2M and other recognized radiological companies to provide an independent third party analysis of the data. He mentioned CH2M has been in contact with Dr. Covello to consult on the outreach messaging efforts; Dr. Covello indicated he would be available after the New Year.

Pat Brooks explained this project is BRAC's number one priority, and they will be putting all their efforts toward facilitating its completion.

Scott Hay presented what has been accomplished so far, and explained the technical approach to the project.

Pat Brooks reiterated the challenges of balancing the aggressive schedule with the thorough analysis this project demands. He indicated a substantial amount of rework has taken place, including past efforts by RASO and Tetra Tech, using approaches that identified anomalous data. It was mentioned there were additional accusations after those efforts were completed. The CH2M team will perform an independent analysis that will include reviewing those efforts as well as performing additional analysis of the data.

Technical Approach

Scott Hay presented the phased approach and accomplishments to date.

Questions were raised about the database regarding how it was going to be examined. Scott Hay and Pat Brooks explained the first steps are to determine the completeness of the data set. Sample IDs can be used to break out survey units, and arrange them by parcel to form data subsets.

A discussion was had about why 2006 was determined as the starting point. The EPA expressed concerns that Tetra Tech was working at Hunters Point in the 1990s and their Health Physicists have identified anomalies in some of the pre 2006 data that they reviewed. Pat Brooks explained that 2006 was used as the cutoff because that was when the TCRA to remove sewer lines began, and everything before that was characterization and preliminary surveys, not used to determine final status. It was decided that any data that was used for decision making needs to be reviewed, and Derek Robinson and Pat Brooks agreed to look into the data that was used to determine work was complete. EPA, DTSC, and the project team agreed if the pre 2006 data was superseded by other work done after 2006, it does not need to be analyzed.

A discussion was held regarding scope. It was explained that during the initial phase, only soil data will be reviewed. In later phases of the project, buildings scans and gamma statics will be evaluated as well. Items such as lab EDDs and field notebooks will be requested as needed as potential issues are identified.

Lily Lee expressed they have been getting a lot of questions on parcels that have already been transferred. Scott Hay explained that we are including all locations where Tetra Tech has worked, and analyzing all of their data. Further concerns were expressed regarding the data that does not show any obvious anomalies. It is her opinion that since Tetra Tech has disclosed that data has been falsified, we cannot say that the data is reliable even though the statistical tests do not turn up any results. Scott Hay and Bob Kirkbright explained that our statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified. It was agreed that areas of highest potential risk should be the priority.

Sheetal Singh asked questions about what types of tests were going to be run, and how it is known whether they are effective. Scott Hay explained we will be using a test on the data sets where problems have already been identified, as well as the data set in its entirety. If these tests are able to identify the known problem areas, it will provide confidence in the analysis. Scott Hay went on to describe the statistical test and how the analysis was going to be approached in more detail, and explained that phase two will determine the amount and locations of confirmation sampling.

EPA raised questions of the amount of confirmation sampling, and what approach will be taken if data testing methods do not recommend sampling in places where allegations have pointed to. Scott Hay explained that confirmation sampling will be done to address specific issues, including allegations from former workers, if that is deemed appropriate. It was discussed that allegations of misconduct do not necessarily mean that there is a health risk. Danielle Janda stated that the Navy was fully committed to doing a resampling effort, with the extent to be determined. Scott stated the North Pier will probably be used as a test run analysis.

Pat Brooks mentioned this initial effort will examine static gamma readings, building scans, and soil data; only the soil data will be included in the initial analysis with the target completion in January 2017. Laboratory electronic data and gamma walk-over data has been requested from TetraTech. During the discussion it was noted that split sample results are not in NIRIS, so those would have to be obtained separately from the agency that conducted the analysis.

Community Outreach

Kellie Koenig provided a handout of the proposed format for the Draft Radiological Community Engagement Communications Plan, and presented the Community Involvement objectives, approach, tasks, and schedule. The following was discussed:

The group recommended adding the Water Board and Non-Regulatory City departments to the list of stakeholders. Key stakeholders will be included from all available lists including the 2014 CIP.

Tamsen Drew stated that the City recommends four languages, and with the known local population recommended public documents be provided in English, Spanish, written Chinese, Samoan, and Tagalog.

The communication efforts will include preparation of and frequently updating a FAQ sheet with answers generated through the Tiger Team.

EPA and City of San Francisco representatives expressed the community is very interested in being informed and involved throughout the duration of the project. The topic of fact sheets and the subjects of each one were discussed. It was suggested that a third fact sheet be added between sheet one and two in order to inform public about initial findings and explaining how the Navy is going to proceed. David Yogi of EPA expressed importance of keeping the community involved throughout the process, not just telling them what we did after it was complete.

Derek Robinson expressed his desire to present at the Mayor's Hunters Point Shipyard Citizen's Advisory Committee (CAC). Tamsen Drew stated that the CAC would be interested.

Additional Public Outreach discussion yielded the ideas that will be discussed further:

- Be proactive, not reactive.
- Get the community involved early in the process and bring them along the process to build trust.
- The possibility of EPA getting a third party technical advisor to help communicate technical aspect to the public. Agency grant availability information should be communicated to CBOs.
- Multiple feedback mechanisms for public communication are beneficial.

- Respond as quickly as possible to community concerns and give consistent responses; essential to building trust.
- Create a list of FAQs to facilitate fast and consistent responses to community questions.
- Go to reporters directly to get them involved, so they do not misinterpret what is going on. The Navy has specific reporters they have worked with in the past.
- Local "door to door" outreach has been successful in the past. Coordination with local churches and community groups has also been successful. A community liaison may help facilitate.
- Choose venues that facilitate the open exchange of information.
- Present Navy, EPA, State, City as a unit.
- Look into attending preexisting meetings
- Public stakeholders prefer information via Email.
- The District Supervisor expressed an interest to be involved.
- The community outreach team resolved to have a call twice per month for two months.

Tamsen Drew raised concern about CH2M's past involvement at Hunters Point, and how the community may react to having a company with past history at the site doing the third party evaluation. Bob Kirkbright explained the differences in CH2M's history and what occurred with Tetra Tech. It is recognized that a cohesive message is necessary to explain how the situations were vastly different, including the response by the companies; the CH2M team performing this review will include recognized senior experts from at least three other independent companies; and this effort will receive continuous independent scrutiny by the Federal, State, and Tiger Team members.

David Yogi of the EPA suggested that there are groups that will never change their distrust level and efforts are better spent on stakeholders who want to hear the facts and learn about current activities. He also brought up having a Technical Advisor, separate from CH2M and the Navy. Recommendations included Saul Bloom, and Kai Vetter. Pat Brooks commented that the Navy is working to involve a National Laboratory (such as Argonne National Laboratory), but it has not been contracted due to the time it takes to get them on board.

Bill Franklin discussed 3 key points:

- Need to identify the best forums and look for reasons to say "Yes" to outreach opportunities and venues to exchange information.
- Tiger Team to share public inquiries and answers to ROIs with the group to ensure a consistent message.
- Tiger Team participation in outreach and outreach planning meetings so that stakeholder interaction is productive and respectful.

Action Items

Determine if pre 2006 data was used for decision making – Pat Brooks

Provide library of compiled questions and answers on community outreach to share with team – Lily Lee

Plan twice a month Community outreach team check in meeting – Derek Robinson

Email copy of Draft Radiological Community Engagement Plan Communications Plan to RASO – Kellie Koenig

Responses to Comments
Draft Parcel G Removal Site Evaluation Sampling and Analysis Plan
Former Hunters Point Naval Shipyard, San Francisco, California

The purpose of this document is to address comments on the Draft Parcel G Removal Site Evaluation Sampling and Analysis Plan, dated August 2018, for Former Hunters Point Naval Shipyard, San Francisco, California. The United States Environmental Protection Agency (USEPA), Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH) comments received September 24, 2018 are listed below and responses to comments are provided in bold. The work plan will be updated to address these comments and a draft final version submitted for review.

USEPA Comments

General Comments

1. The SAP Worksheet #9, Project Scoping Session Participants Sheet, states that statistical tests will identify anomalies in the data, including running tests designed to identify instances where data may have been falsified; however, the SAP does not acknowledge that not all instances of falsification may be identified using the statistical tests. Therefore, the investigation must be designed to require that if any sample result from any of the Phase I TUs exceeds the remedial goals (RGs) specified in the Parcel G ROD, then all TUs will require excavation and analysis. Please revise the SAP to acknowledge that statistical tests may not identify all types/instances of falsification so that 100% excavation will be required if any sample from Phase I TUs exceeds RGs.

   See response to USEPA General Comment 2 on the Parcel G work plan. The Executive Summary and Worksheets 9, 11, 14, and 17 have been updated accordingly.

2. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 1, State the Problem, does not describe how soil background values will be developed for all fill types for Ra-226 and other naturally occurring radioactive material (NORM)/fallout radionuclides. There is no proposal to separate results by fill type in the Work Plan and this would likely require a number of additional samples to generate background values for each soil type. Furthermore, SAP Worksheet #17, Sampling and Survey Design and Rationale, states that "additional sample locations at Bayview Park or other reference areas may be added as necessary to characterize different soil types and depositional areas," but there are no criteria for this decision and insufficient details that explain how this would be done (e.g., how soil types will be determined, the number of required soil samples per soil type, how reference background areas would be expanded, etc.). Please revise the SAP to provide detailed criteria for evaluating whether background values will be calculated for different soil types, including the number of required samples and how reference background areas will be expanded to cover multiple fill types.

   Because the HPNS soil that will be investigated as part of this SAP is mostly fill and has been homogenized, there is no current plan to collect background data/develop background data sets for individual soil types. However, because the background data may be used for other projects at HPNS, the soil lithology will be logged and once data is available and evaluated. If

there are significant differences in the analytical results by soil type, the SAP includes the flexibility for collecting additional samples if needed for further characterization.

3. The SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 3, Identify Inputs to the Objective, inputs include performing a gamma scan survey to identify biased soil sample locations; however, the SAP does not propose a scanning survey method to identify any potential remaining Sr-90 radiological objects. Please revise the SAP to discuss how Sr-90 radiological objects will be identified.

   See response to USEPA Specific Comment 8 on the Parcel G work plan. The details on scanning are included in the Parcel G work plan and references to the work plan are provided in the SAP.

4. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements Step 5, Develop Decision Rules, is inconsistent with the Parcel G ROD. Step 5 states "If the building and soil investigation results demonstrate that site conditions are not compliant with the Parcel G RAO [remedial action objective] and exceed background levels, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA's current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014a). A Removal Site Evaluation Report will be developed to include recommendations for further action." However, the ROD requires each sample result meet the RGs, therefore any reference to assessing risk must be applied within the context of meeting the RGs.

   Please revise the SAP to require remediation of any location where one or more sample results exceed RGs.

   See response to USEPA General Comment 2 on the Parcel G work plan. Worksheet 11 has been updated to reflect the response.

5. The number of surface samples is insufficient. Under the SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 5, Develop Decision Rules, the Background Evaluation subsection states that the statistical difference between data sets will be evaluated using the nonparametric Kruskal-Wallis (KW) test by comparing the calculated p-value against 0.05 significance level. However, background data sets only propose to collect five surface samples at each on-site location, which does not provide a sufficient data pool for estimating population parameters. The number of surface samples per on-site reference background area (RBA) location should be increased to provide sufficient data for statistical evaluation. In addition, the off-site RBA location should include sampling for subsurface soils. Please increase the number of surface samples at each on-site RBA and propose collecting subsurface samples at the off-site RBA.

   See response to USEPA General Comments 12b and 12d on the Parcel G work plan. The number of samples has been increased accordingly throughout the SAP.

6. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements Step 5 – Develop Decision Rules does not state what investigative actions will be taken if the additional six inches of the trench sidewalls and floors has ROCs above RGs. Scanning and/or sampling of the trench sidewalls and floors should be conducted to investigate the location and extent of

any remaining contamination. Please revise the SAP to include this requirement and to include this approach in the data quality objectives in Worksheet #11.

See response to USEPA General Comment 4 on the Parcel G work plan. Text in the Executive Summary and Worksheets 11, 14, and 17 have been updated to include in situ investigation/remediation.

7. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements Step 6 – Specify the Performance Criteria proposes to analyze soil samples for U-238 if Ra-226 is detected to confirm estimates of the background contribution of Ra-226. Per previous EPA comments, all uranium and thorium isotopes should be analyzed and reported by alpha spectroscopy for background evaluations. Please revise the SAP to require alpha spectroscopy of all uranium and thorium isotopes for site samples with elevated Ra-226 results.

   See response to USEPA General Comment 19 on the Parcel G work plan. Worksheet 11 has been updated accordingly.

8. Site samples should be analyzed for the same radionuclides as the RBA samples. SAP Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Step 6, Specify the Performance Criteria, states that all RBA samples will be analyzed by the respective method for the radionuclides listed in Worksheets #15a, #15b, #15c, and #15d, which include most primordial and decay chain radionuclides by gamma spectrometry and isotopic uranium, thorium, plutonium, and americium. Statistical tests will be conducted to compare soil data sets from surface gamma scan surveys, and surface and subsurface analytical concentrations against different identified soil types and against each RBA per sample depth. However, it is unclear how this data will be used in a background evaluation of site sample results since the SAP proposes to only analyze site samples for a limited number of radionuclides and to only perform alpha spectrometry analysis for U-238 if Ra-226 is detected in the gamma spectrometry analysis at concentrations greater than the RG. Per previous Regulatory Agency request, all site samples should be analyzed for the same radionuclides as the RBA samples. At a minimum, the requirement to analyze samples with Ra-226 concentrations above the RG for all uranium and thorium isotopes should be included in the SAP. Please revise the SAP accordingly.

   See response to USEPA General Comment 19 on the Parcel G work plan. Worksheets 11 and 17 have been updated accordingly. Site samples will be analyzed for site-specific ROCs, as described in Worksheet 17.

9. SAP Worksheet #14, Summary of Project Tasks, does not discuss potential soil types, including those that are not native to the Bayview Hunters Point area, or how excavated soil will be segregated by soil type. Some fill has been determined to be granite from the Sierra, which has a very different radiological signature from local soil and rock. Also, the sand near the former theater is a unique fill type. While the backfill in the trenches is likely well mixed, the sidewall/floor unit (SFU) soil may not be, but there is no proposal to segregate this material by soil type during excavation. Also, use of the soil sorting system would preclude segregation by soil type. It may be possible to segregate SFU soil by soil type on a radiological screening yard (RSY) pad. Please revise the SAP to provide procedures for segregating SFU soil by soil type.

   The lithology of excavated soil will be noted in the field; however, separation of excavated soil by soil type is not planned.

10. SAP Worksheet #15a, Reference Limits and Evaluation Soil Gamma Spectroscopy requires a Minimum Detectable Concentration (MDC) for cesium-137 (Cs-137) of 0.05 picoCuries per gram (pCi/g), but the laboratory SOP provided quotes a Cs-137 detection limit of 0.1 pCi/g with a 500 gram dry sample. This can be remedied easily by using a counting geometry that would allow for twice the weight, increasing the count time by a factor of 4, or a combination of the two to reach the required detection limit of 0.05 pCi/g. Please revise the SAP to include the requirement that the contracted laboratory to meet the Worksheet #15 MDCs.

    The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDCs specified in Worksheet 15a with larger aliquots and/or longer count times. A footnote was added for clarification.

11. SAP Worksheet #17, Sampling and Survey Design and Rationale is incomplete because it does not discuss whether soil samples collected from areas around Buildings 351, 364, and 365 identified in the Historical Radiological Assessment (HRA) as locations where Plutonium-239 (Pu-239) was used will be analyzed for Pu-239 as a requirement. Please revise the SAP to include a requirement to analyze all site soil samples for Pu-239 that are collected from trenches near or around all Parcel G buildings identified in the HRA as being associated with the use or disposal of Pu-239.

    See CDPH Specific Comment 49 and the response on the Parcel G work plan. Worksheet 17 has been updated accordingly.

12. SAP Worksheet #17, Sampling and Survey Design and Rationale is incomplete because it does not require Plutonium-239 (Pu-239) analysis for all site soil samples collected from trench units near or around Buildings 351A, 364, and 365, which were identified in the Historical Radiological Assessment (HRA) as locations where Pu-239 was used and is a ROC. The SAP states Pu-239 analyses will only be conducted for soil samples with Cs-137 or Sr-90 detections at or above the respective RG. However, the SAP states Sr-90 analysis will only be performed for 10% of the samples, therefore this criterion is not appropriate for TUs near buildings that previously handled Pu-239. Please revise the SAP to include a requirement to analyze all site soil samples from trenches near or around all Parcel G buildings identified in the HRA as being associated with the use or disposal of Pu-239.

    Pu-239 is only an ROC at the Former Buildings 317/364/365 Site; therefore, analysis for Pu-239 will be performed for 10 percent of systematic soil samples associated with the SUs at the former Buildings 317/364/365 Site. The 10 percent will be selected at random. Additional Pu-239 analyses will be performed on samples with Cs-137 or Sr-90 results at or above the RG. The text in Worksheet 17 has been updated for clarification.

13. SAP Worksheet #17, Sampling and Survey Design and Rationale, is inconsistent with Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, because Worksheet #17 does not propose segregating sidewall and floor unit soil on RSY pads. Please resolve this discrepancy.

    The segregation of soil applies to both the soil sorter and RSY pads and the text in the Phase 1 Trench Unit sections in Worksheets 14 and 17 were updated for clarification. References to these worksheets are provided in Worksheet 11.

14. Previously submitted comments/concerns summary: The SAP gives details related to *Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California, June 15, 2018* ("Work Plan"). Therefore, many of the comments that EPA made on the draft Work Plan1 also apply to the SAP. The draft SAP arrived for review at the same time that EPA submitted its comments on the Work Plan, so the Navy would not have had the opportunity to incorporate the Work Plan comments into the SAP. For convenience, this comment summarizes some examples of the Work Plan comments that are also relevant to the SAP. We appreciate that the Navy stated its intentions to incorporate regulatory comments already given for the Work Plan into the relevant corresponding aspects of the next version of the draft SAP.

    a. The SAP states that if site conditions are not compliant with the Parcel G ROD remedial action objectives (RAOs), then the data will be evaluated to determine whether site conditions are protective of human health using the EPA's current guidance on Radiation Risk Assessment at CERCLA Sites rather than that exceedances will be excavated.

       See response to USEPA General Comment 3 on the Parcel G work plan. Accordingly, the text has been revised throughout the SAP.

    b. The SAP Executive Summary and Worksheet #11 Decision Rules do not state that if contamination is identified in any of the initial 33 percent (%) of trench units/survey units (TUs/SUs), then all TUs/SUs in Parcel G will require excavation and investigation.

       See response to USEPA General Comment 2 on the Parcel G work plan. Accordingly, the text has been revised throughout the SAP.

    c. The SAP does not include all the technical information requested for the proposed sample analyses, including a copy of all sampling and analytical standard operating procedures (SOPs) and as applicable, nuclide libraries used to quantitate results.

       All analytical SOPs and nuclide libraries were checked and are included in Attachment 3.

    d. Analysis and reporting of all uranium and thorium isotopes by alpha spectroscopy for samples with elevated radium-226 (Ra-226) are not specified.

       See response to USEPA General Comment 19 on the Parcel G work plan. Accordingly, the text has been revised throughout the SAP.

    e. A requirement to report count times, results, counting and total propagated uncertainty for all radiological results is not specified.

       A footnote was added in Worksheet 14 to specify that reported radiological results will, at a minimum, include count times, results, counting uncertainty, and total propagated uncertainty.

    f. Only six locations are proposed for collection of core samples in Phase 2 trenches rather than at the number of locations as identified using the Multi-Agency Radiological Site

Survey and Investigation Manual (MARSSIM) formulas for performing a statistical analysis.

See response to USEPA General Comment 5 on the Parcel G work plan. The SAP has been updated to include 18 boring locations in Phase 2 TUs.

g. The SAP does not state how large the SUs will be for Phase II, or how the size will be determined. Note that per MARSSIM guidance, Class 2 land areas should not exceed 10,000 square meters. EPA expects the survey units to be the same size as in previous work, i.e. the size of soil survey units will not exceed 1,000 square meters and the building survey unit sizes will not increase.

As stated in Worksheet 14, the size and boundaries of TUs/SUs will be based on previous plans and reports. The specific TU/SU sizes are detailed in the Parcel G work plan.

h. The SAP discusses the soil sorting operations used to screen excavated soil but does not include an operations plan or include the specifics about which radiological properties will be monitored or how alarms will be set to segregate soils that will receive further radiological investigation/analysis.

The SAP only provides a summary of the soil sorting operations and refers to the Parcel G work plan text which contains a more detailed description. A contractor-specific Soil Sorting Operations Plan will be prepared and submitted for regulator review.

i. The SAP does not provide the basis for the number of samples planned to be collected from TUs/SUs. It also does not propose incorporating the variance from newly collected data in MARSSIM equation 5-1 for updating the required number of samples to be collected from each survey unit as new data is collected as part of the Parcel G investigation. EPA comments recommend using MARSSIM procedures to calculate those.

See response to USEPA General Comment 5 on the Parcel G work plan.

j. The SAP does not address the instrumentation and survey parameters for investigating the potential presence of radiological objects such as deck markers containing Strontium-90 (Sr-90) in soil.

See response to USEPA Specific Comment 8 on the Parcel G work plan.

k. The SAP does not provide sufficient information to fully evaluate the sufficiency of the buildings investigation. It also does not propose updating the building release criteria using the EPA Building Preliminary Remediation Goal (BPRG) Calculator for radionuclides to ensure the limits remain protective of human health.

See response to USEPA General Comment 9 on the Parcel G work plan.

l. The SAP does not explain the assignment of MARSSIM classifications to all building survey units.

   Worksheet 17 was updated to explain the MARSSIM survey unit classifications for buildings.

m. The SAP does not state how the number of static measurements was determined for building survey units and does not propose incorporating the variance from newly collected data in the MARSSIM equation 5-1 for updating the number of static measurements required to be collected from each survey unit as new data is collected as part of the Parcel G building investigation.

   See response to USEPA General Comment 5 on the Parcel G work plan.

n. The SAP does not state if wipe samples will be sent to the laboratory for destructive analysis to determine which radionuclide is contributing to the radiation if release limits are exceeded for gross alpha or gross beta.

   Swipe or material samples may be sent to the offsite laboratory for further analysis and this was added to the SAP.

o. The SAP proposes to evaluate background data for outliers using Dixon's and Rosner's statistical outlier tests, both of which assume the data are normally distributed. Population distributions are often not normally distributed; therefore, population distribution and careful evaluation of background data should be performed to fully justify removing any data points.

   See response to USEPA Specific Comment 25 on the Parcel G work plan.

p. The SAP does not propose analyzing and reporting all naturally occurring radionuclides in site samples that are also Radionuclides of Concern (ROCs) to determine if the uranium-238 (U-238) and thorium-232 (Th-232) decay chains are in secular equilibrium prior to conducting any outlier evaluations or comparison of ROCs to background levels of radionuclides.

   See response to USEPA General Comment 19 on the Parcel G work plan. The SAP has been updated accordingly.

Please ensure that the SAP is revised to address these issues.

See responses to comments a through p above.

Specific Comments

1. SAP Worksheet #9, Project Scoping Session Participants Sheet, Pages 35, 36: Please include Dave Kappelman in this worksheet.

   Dave Kappelman was not on the list of attendees for the December 7, 2016 meeting.

2. SAP Worksheet #14, Summary of Project Tasks, Page 59: The Data Management subsection does not provide sufficient data management requirements. The worksheet states that electronic

copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device and further states additional details are provided in Worksheet #29 and the Parcel G Work Plan Appendix B SOPs. Worksheet #29 states that data will be maintained in project files and stored for a minimum of 7 years in accordance with the CLEAN 9000 contract requirement. However, given the nature of the planned future use of the site for residential re-development, please revise the SAP to propose retaining files for a longer period of time.

Worksheets 14 and 29 were updated to indicate that analytical data will be stored in NIRIS and will be included in final reports.

3. SAP Worksheet #14, Summary of Project Tasks, Page 59: The Data Management subsection states that project data will be documented in accordance with the Parcel G Work Plan Appendix B. The data management SOP in the Parcel G Work Plan Appendix B, SOP RP-114, Control of Radiation Protection Records, defines documentation requirements for "radiation protection records." Therefore, it appears the intent of this SOP is to govern worker protection records rather than environmental data. In addition, neither Worksheet #29 nor the Parcel G Work Plan specifies the location of the storage facility where these records will be maintained. Please revise the Parcel G Work Plan or SAP to include a SOP, or additional explanation for the requirements storing all project documents, to ensure the integrity and long-term retention of such records.

   Worksheets 14 and 29 were updated for clarification on environmental data storage, including the locations for file storage.

4. SAP Worksheet #23, Analytical SOP References, Pages 93-94: This worksheet includes a listing of methods and SOPs, however some of the SOPs referenced in this worksheet are not included in Attachment 3, Laboratory SOPs. For example, SOP GL-RAD-A-013, The Determination of Gamma Isotopes, Revision 26, February 2017 is not included in Attachment 3. Please revise the SAP to include all analytical SOPs listed in Worksheet #23 and to ensure the nuclide libraries are included for all relevant methods.

   All analytical SOPs and nuclide libraries were checked and are included in Attachment 3.

DTSC Comments

General Comments

1. Executive Summary, paragraph 2 refers to allegations. See DTSC draft Work Plan comment #9.

   See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP has been updated accordingly.

2. Executive Summary, Soil Investigations -See DTSC draft Work Plan comment #6 regarding selection of trench and building soil survey units to be sampled.

   See response to USEPA General Comment 13 on the Parcel G work plan. The SAP has been updated accordingly.

3. Executive Summary, Soil Investigations, paragraph 3 -See DTSC draft Work Plan comment #7 regarding the 6 inches of excavated soil along trench walls.

See response to USEPA General Comment 4 on the Parcel G work plan. The SAP has been updated accordingly.

4. Executive Summary, Soil Investigations, paragraph 4 -See DTSC draft Work Plan comment #8 regarding Phase II.

   See response to USEPA General Comment 6 on the Parcel G work plan. The SAP has been updated accordingly.

5. Executive Summary, Data Evaluation, last paragraph -See DTSC draft Work Plan comments #4 and 5.

   See response to USEPA General Comment 3 and CDPH General Comment 1 on the Parcel G work plan. The SAP has been updated accordingly.

6. SAP Worksheet #9 -Project Scoping Session participants Sheet -Generally information pertaining to community outreach is not included in an SAP. Suggest retitling Action Items to SAP Specific Action Items and delete bullet two through four.

   Worksheet 9 was revised as suggested.

7. SAP Worksheet #10, Conceptual Site Model, par. 2 -See DTSC draft Work Plan comment #9

   See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP has been updated accordingly.

8. SAP Worksheet #10, Conceptual Site Model, pg. 43, Current Status -Parcel UC- 2 should be added as a Parcel that has been transferred to San Francisco.

   Worksheet 10 was revised as requested.

9. SAP Worksheet #11, Step 5 Develop Decision Rules, Bullet 2 and Step 6, Specify the Performance Criteria last bullet -See DTSC draft Work Plan comment #5

   See response to CDPH General Comment 1 on the Parcel G work plan. The SAP has been updated accordingly.

10. SAP Worksheet #11, Step 5 and 6 -Reference Background Areas data evaluation process should be revised to reflect comments that will be provided by the U.S. EPA on the draft SAP.

    Worksheet 11 has been revised to reflect the comments on the Parcel G work plan and SAP.

11. SAP Worksheet #11, Step #7, Develop the Plan for Obtaining Data -See DTSC draft Work Plan comment #8.

    See response to USEPA General Comment 6 on the Parcel G work plan. The SAP has been updated accordingly.

12. SAP Worksheet #14, Phase 1 Trench Unit - This section indicates that excavated soil will "undergo radiological assay following either the automated soil sorting process or Radiological

Screening Yard (RSY) pad process." CDPH EMB has indicated that the automated soil sorting process must be approved by CDPH staff prior to initiation of this method. Most likely, the US EPA will also require the same. Therefore, please revise this Section as follows: " ....undergo radiological assay following either the automated soil sorting process (if approved by CDPH and US EPA) or Radiological Screening Yard (RSY) pad process."

The Soil Sorting Operations Plan will be submitted to the regulatory agencies for review and concurrence. See response to CDPH Specific Comment 12 on the Parcel G Work Plan.

13. SAP Worksheet #14, Phase 2 Trench Unit - See DTSC Work Plan comment #8

    See response to USEPA General Comment 6 on the Parcel G work plan. The SAP has been updated accordingly.

14. SAP Worksheet #14, Phase 2 Trench Unit, paragraph 4 - See DTSC Work Plan comment #1. SAP Figures will need to be revised accordingly.

    See response to USEPA General Comment 2 on the Parcel G work plan. The figures have been updated accordingly.

15. SAP Worksheet #14, Phase 2 Survey Unit - See DTSC Work Plan comment #1. SAP Figures will need to be revised accordingly.

    See response to USEPA General Comment 2 on the Parcel G work plan. The figures have been updated accordingly.

16. SAP Worksheet #14, Site Restoration and Demobilization - If imported fill material is required to complete backfill requirements, DTSC's guidance, Information Advisory Clean Imported Fill Material must be used.

    Worksheet 14 was revised as requested.

17. SAP Worksheet #17, Sampling and Survey Design and Rationale - See DTSC Work Plan comment #1. SAP Figures will need to be revised accordingly. Additionally, DTSC defers to CDPH and US EPA to provide comments on the technical aspects of this worksheet.

    See response to USEPA General Comment 2 on the Parcel G work plan. The figures have been updated accordingly.

18. SAP Worksheets - DTSC defers to CDPH and US EPA to provide comments on all technical radiological worksheets provided in the SAP.

    Comment noted.

CDPH Comments

General Comments

1. Please note that CDPH-EMB utilizes Section 30256 in Title 17 of the California Code of Regulations (17 CCR 30256) to render a decision to concur with a Radiological Unrestricted

Release Recommendation (RURR). As a result, CDPH-EMB requires a final status survey report that compares the distribution of data from the survey site with applicable reference area data and documents the remediation efforts. The final status survey should document and explain reasonable efforts that have been made to remediate the site.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP has been updated accordingly.

2. CDPH-EMB received the draft sampling and analysis plan (SAP) three days after submittal of our comments on the draft Parcel G Evaluation Work Plan (June, 2018) on August 14, 2018, because of this we understand that our comments on the Work Plan have not been reflected in the draft SAP. Therefore, to avoid repeating our previous comments, many of EMB's comments on the draft SAP refer to specific comments on the draft Work Plan. The comments submitted for the draft Parcel G Evaluation Work Plan are attached for reference purposes.

   Comment noted, the SAP was updated per the Parcel G work plan comments and responses to comments.

Specific Comments

3. Executive Summary. page five. paragraph two. sentence four, "There have been various allegations of data manipulation or falsification committed by TtEC employees and their subcontractors during the TCRA." These allegations have been admitted to by Tetra Tech Inc., NJ; in a 10/11/2016 Nuclear Regulatory Commission Enforcement Action, EA-15-230; specifically that employees of Tetra Tech deliberately falsified soil sample records on several occasions at HPNS. Additionally, two Tetra Tech Radiological Supervisors, Justin Hubbard, and Stephen Rolfe, both supervisors for Tetra Tech at HPNS; pled guilty to falsifying soil samples in Federal Court and were incarcerated. Please correct the record in this, and in any similar references in this document (including, but not limited to, work sheets, attachments and appendices) to "allegations" by noting that both the Tetra Tech admission plea in the 10/11/2016 Nuclear Regulatory Commission Enforcement Action, EA-15-230 and the subsequent guilty pleas of the two individuals noted above.

   See response to USEPA Specific Comment 2 on the Parcel G work plan. The Executive Summary has been updated accordingly.

4. <u>Executive Summary, (Soil Investigations), page five, paragraph one, sentence one,</u> *"Soil investigations will be conducted in a phased approach at the following areas in Parcel G: ... "* Please see EMB comment number 10.

   See response to CDPH Specific Comment 10 on the Parcel G work plan. The SAP was updated accordingly.

5. <u>Executive Summary, (Soil Investigations), page five, paragraph one, sentence two</u>, *"Phase 1 includes investigation of a targeted group of trench units (TUs) and survey units (SUs). Of the 63 former sanitary sewer and storm drain TUs, 21 were selected for the Phase 1 investigation."* Please see EMB comment number 11.

   See response to CDPH Specific Comment 11 on the Parcel G work plan. The SAP was updated accordingly.

6. Executive Summary, (Soil Investigations), page six, paragraph two, sentence two, "*2) soil may be processed and scanned using soil segregation technology."* Please see EMB comment number 12.

   See response to USEPA Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

7. Executive Summary, (Soil Investigations), page six, paragraph two, sentence three, *"Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide ex situ scanning and sampling of the trench sidewalls and floors."* Please see EMB comments numbers 13 and 14.

   See responses to CDPH Specific Comments 13 on the Parcel G work plan. The SAP was updated accordingly.

8. Executive Summary, (Soil Investigations), page six, paragraph three, sentence five, *The data will be compared and evaluated to provide representative RBA data sets that will be used to evaluate site investigation data to support a final decision on whether residual radioactivity is found to exceed the RGs, thus requiring further remediation."* Please see EMB comment number 7.

   See response to CDPH Specific Comment 7 on the Parcel G work plan. The SAP was updated accordingly.

9. Executive Summary, (Building Investigations), page six, paragraph one, sentence one, *"Building investigations will be performed at the following structures in Parcel G ... "* Please see EMB comment number 8.

   See response to CDPH Specific Comment 8 on the Parcel G work plan. The SAP was updated accordingly.

10. Executive Summary, (Data Evaluations), page seven, paragraph three, sentence one, *"If the investigation results demonstrate that site conditions are not compliant with the Parcel G ROD RAO, then the data will be evaluated to determine whether site conditions are protective of human health using the United States Environmental Protection Agency's (USEPA's) current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014a)."* Please see EMB comment number 19.

    See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated accordingly.

11. SAP Worksheet #10-(Conceptual Site Model), page 39, paragraph two, sentence one, *"Following the investigation and removal actions, there were allegations that TtEC potentially manipulated and falsely represented data."* Please see EMB Specific Comment number 3 of this memo.

    See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP was updated accordingly.

12. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 1, (State the Problem), page 45, paragraph one, sentence one, *''There have been various*

allegations of data manipulation or falsification committed by a contractor during past sanitary sewer and storm drain removal actions and current and previous soil and building investigations in Parcel G." Please see EMB Specific Comment number 3 of this memo.

See response to USEPA Specific Comment 2 on the Parcel G work plan. The SAP was updated accordingly.

13. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements. Step 5, (Develop Decision Rules), page 45. bullet one. sentence two, *"The RACR will describe the results of the investigation, and will provide a demonstration that radioactivity levels meet the Parcel G RAO or represent background conditions."* Please replace the word, "or", with the word, "and".

    See response to USEPA General Comment 2 on the Parcel G work plan. Worksheet 11 was updated accordingly.

14. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 5, (Develop Decision Rules), page 45, bullet one, sentence one, *"If the building and soil investigation results demonstrate that site conditions are not compliant with the Parcel G RAO and exceed background levels, then the data will be evaluated to determine whether site conditions are protective of human health using USEPA 's current guidance on Radiation Risk Assessment at CERCLA Sites (USEPA, 2014a),* Please see EMB comment number 19.

    See response to CDPH General Comment 1 on the Parcel G work plan. Worksheet 11 was updated accordingly.

15. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 6, (Specify the Performance Criteria). page 45. bullet one, inset one. sentence two, *"Analysis will be based on the site-specific ROCs (Worksheet #17). All soil samples at a minimum will be assayed by gamma spectroscopy for 137Cs and 226Ra with at least 10 percent of samples receiving gas flow proportional analysis for 90Sr. Additionally, if the laboratory results indicate concentrations of 137Cs above its RG (Worksheet #15a), the sample will be analyzed for 90Sr. If the laboratory results indicate the presence of concentrations of 137Cs or 90Sr at or above the respective RG (Worksheets #15a and #15c), additional analysis via alpha spectroscopy for 239Pu will be performed (Worksheet #15b).* Please see EMB comments numbers 48 and 49.

    See responses to CDPH Specific Comments 48 and 49 on the Parcel G work plan. Worksheet 17 was updated accordingly.

16. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), page 45, Soil Investigation, bullet one, inset one, sentence one, *"Phase 1 TUs/SUs - The radiological investigation will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewers and storm drains, and 14 of the 28 SUs associated with surface soil at building sites in Parcel G (see Figure 11-1). The Phase 1 TUs/SUs will be investigated using gamma scan surveys and soil sampling as described in Worksheets #14 and #17."* Please see EMB comment number 22.

    See response to CDPH Specific Comment 22 on the Parcel G work plan. The SAP was updated accordingly.

17. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), Soil Investigation, page 45, bullet one, inset two, sentence one, *"Phase 2 TUs/SUs - Additional soil sampling will be conducted on the remaining 42 TUs and 14 SUs in Parcel G (see Figure 11-1). The Phase 2 TUs/SUs will be investigated with soil sampling and scanning of soil cores as described in Worksheets #14 and #17.* Please see EMB comment number 25.

    See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated accordingly.

18. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), Soil Investigation. page 45, bullet one, inset three, sentence one, *"The soil samples collected as part of the Phase 1 and Phase 2 investigations will be analyzed for the applicable ROCs by accredited offsite laboratories and the results will be evaluated as described in Step 6."* Please see EMB comment number 21.

    See response to CDPH Specific Comment 21 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

19. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Develop the Plan for Obtaining Data), Soil RBA Investigation, page 45. inset one, bullet one, sentence one, *"Soil samples will be analyzed for the applicable ROCs along with NORM radionuclides and fallout radionuclides by accredited offsite laboratories (Worksheet #17)."* Please see EMB comment number 25.

    See response to CDPH Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

20. SAP Worksheet# 11-Project Quality Objectives/Systematic Planning Process Statements, Step 7, (Building lnvestigation),page 45, inset one, sentence one, *“Building investigations will be conducted on floors, wall surfaces, and ceiling surfaces, and will consist of alpha and beta scan surveys, alpha-beta static measurements, and alpha-beta swipe samples as described in Worksheets #14 and #17.")."* Please see EMB comment number 15.

    See response to CDPH Specific Comment 15 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

21. SAP Worksheet #12-(Field Quality Control Samples) - page 49, Soil Measurement Performance Criteria Table - Field QC Samples, Split Sample, Frequency, *"To be determined by the stakeholders on a case by case basis for each site."* Please retain all soil samples obtained for regulatory agency confirmation.

    Worksheet 12 was updated to state that soil samples will be retained until the contractor for Parcel G soil work demobilizes from the site.

22. SAP Worksheet #13-Secondary Data Criteria and Limitations, page 51;(How Data Will be Used), *"To determine whether site conditions in soil and building surfaces are compliant with the Parcel G ROD RAO (Navy, 2009), analytical and building data will be compared to the RGs for Parcel G ROCs."* Please see EMB comment number 19.

See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

23. SAP Worksheet #14-Summary of Project Tasks (Automated Soil Sorting System), page 56, paragraph one, sentence one, *"Soil sorting systems are radiological monitoring and processing systems designed to perform real-time segregation of soil into two distinct bins based upon the soil's radiological properties"* Please see EMB comment number 12.

    See response to USEPA Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

24. SAP Worksheet #14-Summary of Project Tasks (Phase 2 Trench Unit), page 56, paragraph one, sentence two, *"Subsurface soil samples will be collected as described in Worksheet #21 and Attachment 2)."* Please see EMB comment number 25.

    See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

25. SAP Worksheet #15a-Reference Limits and Evaluation Soil Gamma Spectroscopy, (Laboratory-Specific Limits), MDC (pCi/g), page 63. The limits in this table of 0.05 and 0.1 pCi/g respectively for Cs-137 and Ra-226; appear to be less than the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure,GL-RAD-A-013 Rev 26, (The Determination of Gamma Isotopes), Section 3.1, *"A typical detection limit is 10 pCi/L or 0.1 pCilg (based on Cs-137)"*: as well as the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-008 Rev 15, GEL Laboratories, LLC (GEL). (Determination of Radium-226), Section 3.2, *"Method Detection Limit (MDL): typical minimal detectable activity (MDA) for samples analyzed for Ra-226 is 1pCi/L or 1pCi/G."* Please resolve these differences.

    The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDCs specified in Worksheet 15a with larger aliquots and/or longer count times. A footnote was added for clarification.

26. SAP Worksheet #15b-Reference Limits and Evaluation Soil Alpha Spectroscopy, (Laboratory-Specific Limits), MDC (pCi/g), page 64. The limits in this table of 0.1 and 0.5 pCi/g respectively for Ra-226 and Pu-239/240; appear to be less than the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-011 Rev 26, GEL Laboratories, LLC (GEL). (The Isotopic Determination of Americium, Curium, Plutonium and Uranium), Section 3.1. *"Method Detection Limit (MDL Typical minimum detectable activity (MDA) for samples analyzed for Am/Cm/Pu/U is 1 pCi/L or 1 pCilg for all isotopes."* Please resolve these differences for Pu-239/40.

    The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDCs specified in Worksheet 15b with larger aliquots and/or longer count times. A footnote was added for clarification.

27. SAP Worksheet #15c-Reference Limits and Evaluation Soil Gas Flow Proportional Counting: (Laboratory-Specific Limits). MDC (pCi/g), page 65. The limits in this table for Sr-90, 0.15 pCilg;

appear to be less than the Method Scope, Applicability, And Detection Limit listed in Standard Operating Procedure, GL-RAD-A-004 Rev 18, GEL Laboratories, LLC (GEL). (The Determination of Strontium 89/90 in Water, Soil. Milk, Filters, Vegetation, and Tissues), Section 3.1, *"Method Detection Limit (MDL): Typical minimum detectable activity (MDA) for samples analyzed for Sr-89 and Sr-90 is 2 pCi/L or 2 pCi/g."* Please resolve these differences.

The SOPs reflect standard method MDCs that are the default values if a project does not specify a site-specific detection limit. However, the lab can achieve the lower MDC specified in Worksheet 15c with larger aliquots and/or longer count times. A footnote was added for clarification.

28. SAP Worksheet #17-Sampling and Survey Design and Rationale (Soil Investigation). page 73 paragraph one, sentence two, *"The radiological investigation design and rationale are based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement to demonstrate compliance with the Parcel G ROD RAO".* Please see EMB comment number 19.

    See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

29. SAP Worksheet #17-Sampling and Survey Design and Rationale (Soil Investigation). page 73 paragraph three, sentence two, "Additionally, Phase 2 SU samples collected from the Former Building 317/364/365 Site will also have 10 percent of samples receiving alpha spectroscopy analysis for 239Pu. If the laboratory results indicate concentrations of 137Cs above its RG (Worksheet #15a), the sample will be analyzed for 90Sr (Worksheet #15c)." Please see EMB comments 48 and 49.

    See response to CDPH Specific Comments 48 and 49 on the Parcel G work plan. Worksheet 17 was updated accordingly.

30. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 1 Trench Unit}, page 73 paragraph one. sentence one. *"Radiological investigations will be conducted on a targeted group of 21 of the 63 TUs associated with former sanitary sewer and storm drain lines (Figure 11-1 and Worksheet #18) to evaluate whether concentrations of ROCs are compliant with the RAO in the Parcel G ROD (Navy, 2009)."*Please see EMB comments numbers 8 and 19.

    See responses to CDPH Specific Comments 8 and CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

31. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 1 Trench Unit), page 74, paragraph two, bullet one sentence one, *"If the automated soil sorting system process is used, 18 systematic soil samples will be collected from each ESU or SFU during assay with the soil sorting system"*. Please see EMB comment 12.

    See response to USEPA Specific Comment 12 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

32. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 2 Trench Unit), page 74, paragraph two, sentence one, *"Within the backfill of each Phase 2 TU boundary, six systematic locations will be cored down to approximately 6 inches below the depth of the previous excavation"*. Please see EMB comment number 25.

    See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

33. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 2 Trench Unit), page 74, paragraph three, sentence one, *"An additional set of 18 systematic samples will be collected from 6 systematic locations representative of the trench sidewalls"*. Please see EMB comment number 25.

    See response to CDPH Specific Comment 25 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

34. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 1 Survey Unit), page 75, paragraph one, sentence one, "The Phase 1 SU investigation will be conducted on a targeted group of 14 of the 28 SUs associated with soil from building sites where only surface soil scanning and sampling were previously conducted (Figure 11-1)". Please see EMB comment number 8.

    See response to CDPH Specific Comment 8 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

35. SAP Worksheet #17-Sampling and Survey Design and Rationale (Phase 2 Survey Unit), page 75, paragraph one, sentence one, *"The Phase 2 SU investigation will be conducted on the remaining 14 of 28 SUs in Parcel G (Figure 11-1)*." Please see EMB comment number 8.

    See response to CDPH Specific Comment 8 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

36. SAP Worksheet #17-Sampling and Survey Design and Rationale (Reference Background Area Investigation), page 76, paragraph two, sentence two, *"In order to simplify the sampling design, an approximately 20-foot by 20-foot square has been established within each of the four historical RBA footprints."* Please see EMB comment number 65.

    See response to CDPH Specific Comment 65 on the Parcel G work plan. The SAP has been updated accordingly.

37. SAP Worksheet #17-Sampling and Survey Design and Rationale (Reference Background Area Investigation), page 76, paragraph two, sentence eight, *"Both surface gamma scan surveys and surface soil samples will be collected from RBA-Bayview to provide a more accurate surface soil data set to represent undisturbed surface soil areas."* Will subsurface soil samples be taken in the Bayview Park RBA? If so, how many subsurface soil samples will be obtained?

    Twenty-five subsurface soil samples be collected from the RBA-McLaren location and the SAP was updated to reflect this.

38. SAP Worksheet #17-Sampling and Survey Design and Rationale (Building Investigation), page 77, paragraph one, sentence two, *"The radiological investigation design and rationale is based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement being to demonstrate compliance with the Parcel G ROD RAO."* Please see EMB comment number 19.

    See response to CDPH General Comment 1 on the Parcel G work plan. The SAP was updated per the Parcel G work plan comments and responses to comments.

39. SAP Worksheet #17-Sampling and Survey Design and Rationale (Building Investigation), page 78, paragraph one, sentence three, *"Parcel G buildings will be divided into identifiable SUs similar in area and nomenclature to the previous final status survey of each building."* The following differences have been identified on comparing the building survey efforts proposed in the Parcel G work plan with the building final status survey reports (from years 2009 and 2010). Please provide justification for the deviation from the original work plan for each building and explain how the recommendations of the Historical Radiological Assessment (2004) are being met.

    a. Building 351A and Crawlspace: Survey units 045, 046, 047, R, S, and U are not being surveyed. Please explain.

       For the Building 351A Crawl Space, former SU-R, SU-S, and SU-U overlapped SU-M, SU-N, and SU-O and will be investigated as SU-M, SU-N, and SU-O during the soil investigation and a footnote was added for clarification.

       SUs 45, 46, and 47 in Building 351A will be surveyed as Class 2 SUs and the Class 2 SUs were added to the figure.

    b. Building 351: Survey Units 039, 040, 052, 053, 054 are not being surveyed. Please explain.

       SUs 39, 40, 52, 53, and 54 in Building 351 will be surveyed as Class 2 SUs and the Class 2 SUs were added to the figure.

    c. Building 366: Survey Units 060 to 068 are not being surveyed. Please explain.

       SUs 60 through 68 in Building 366 will be surveyed as Class 2 SUs and the Class 2 SUs were added to the figure.

    d. Building 401: Survey Units 001 to 022, 030, 031, and 032 to 035 are not being surveyed. Please explain.

       SUs 1 to 22 and 30 to 35 in Building 401 will be surveyed as Class 1 or 2 SUs and are included and/or were added to the figure.

    e. Building 408: Survey Unit 002 is not being surveyed. Why does SU-001 have a different shape compared to the final status survey report (2009)? Please explain.

       SU 2 will be surveyed as a Class 2 SU and was added to the figure.

f. Building 411: Survey Unit-001, 002, 003, 004 are not being surveyed. Have the survey units SU-005 through SU-011 been redrawn? Will the second floor be surveyed? Please explain.

SUs 2 through 11 in Building 411 will be surveyed as Class 1 or 2 SUs and are included and/or were added to the figure. SUs 5 through 11 were not redrawn. The third floor and mezzanine are no longer accessible due to significant safety concerns and therefore SU 1 will not be surveyed. This explanation was added to the Parcel G work plan.

g. Building 439: Survey Unit 003 is not being surveyed. Have the survey units SU-004 through SU-006 been redrawn? Please explain.

The original survey area consisted of two Class 1 SUs (SU 1 and SU 2) on the floors and lower walls of the enclosure, and a Class 2 SU (SU 3) on the enclosure upper walls and ceiling. After remediation was performed in a small area within SU 1, a new Class 1 SU (SU 4) was established within the remediated area, and two Class 2 SUs were established as buffer areas within the enclosure and in a 2-meter perimeter on the outside of the enclosure (SUs 5 and 6, respectively). Because of the overlap of the pre- and post-remediation SUs, the investigation at Building 439 will consist of Class 1 surveys in SUs 1 and 2, and Class 2 surveys in SUs 3 and 6 and the figure was updated to reflect this. The Class 1 survey in SU 1 will capture areas previously surveyed as SU 4 and 5.

40. <u>Attachment B - Standard Operating Procedure (Locating and Clearing Underground Utilities), Services Available for Identifying and Marking Underground Utilities.</u> None of the services that are available for identifying and marking underground utilities listed throughout this appendix are located in the State of California. Please correct.

The SOP was removed from the SAP and work plan. The work plan includes the utility locating process.

41. <u>Attachment B - Standard Operating Procedure Decontamination of Personnel and Equipment Section F, (Heavy Equipment And Tools). page four,</u> *"Steam clean heavy equipment until no visible signs of dirt are observed."* Is it in fact Navy's intent to steam clean heavy equipment and tools as they leave the radiologically controlled areas?

For radiologically controlled areas, equipment and materials will be surveyed and decontaminated based on the referenced SOP and procedures outlined in Section 6 of the Parcel G work plan. Steam cleaning may not be required if dry methods are successful in meeting the radiological release criteria.

Attachment 2
Field SOPs

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
CH2M Document	Soil Sampling	Provides guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig-mounted equipment.
CH2M Document	Logging of Soil Borings	Provides guidance for obtaining accurate and consistent descriptions of soil characteristics during soil sampling operations.
CH2M Document	Decontamination of Equipment and Samples	Provides general guidelines for the decontamination of sampling equipment, and monitoring equipment used in potentially contaminated environments.
CH2M Document	Preparing Field Logbooks	Provides general guidelines for entering field data into logbooks during site investigation and remediation activities.
CH2M Document	Chain-of-Custody	Provides information on chain-of-custody procedures.
CH2M Document	Packaging and Shipping Procedures for Low-concentration Samples	Provides information on preparing, packaging, and shipping low activity radioactive samples for analysis.
RP-100	Radiation Protection Program	Describes the major elements of the Radiation Protection Program.
RP-102	Radiological Posting	Identifies the types of postings necessary and requirements to clearly identify radiological conditions in a specific area or location within an area for consistent posting and control of RCAs. It also specifies the requirements for access into and egress from RCAs.
RP-103	Radiation Work Permits Preparation and Use	Provides direction on the requirements of the application, preparation, approval, issuance, and use of general and specific Radiation Work Permits.
RP-104	Radiological Surveys	Specifies methods and requirements for radiological surveys, and the documentation required for the acquired survey data.
RP-105	Unrestricted Release Requirements	Describes the method of surveying equipment, materials, or vehicles for release for unrestricted use.
RP-106	Survey Documentation and Review	Provides the methodology for documenting radiological surveys and provides criteria for the review of these surveys.
RP-107	Measurement of Airborne Radioactivity	Provides the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples.
RP-108	Count Rate Instruments	Provides the methods for setup, daily pre-operational check, and operation of portable count-rate survey instruments.
RP-109	Dose Rate Instruments	Provides the methods for performing source checks and operating portable gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicron Model Micro Rem.
RP-111	Radioactive Materials Control and Waste Management Plan	Provides guidance and requirements for the control of radioactive materials, including the management of radioactive waste.
RP-112	Dosimetry Issue	Provides consistent methodology for the issuance of radiation monitoring dosimetry devices.

Application and Description of Standard Operating Procedures

SOP Number	SOP Title	Application and Purpose
RP-114	Control of Radiation Protection Records	Describes the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records.
RP-115	Radiation Worker Training	Provides consistent methodology for implementing Radiation Worker Training.
RP-130	Event Reporting and Notification for State of California	Provides a list of California regulatory contacts, a checklist for initiating emergency notifications, and general guidance for notification of incidents.
RP-132	Radiological Protective Clothing Selection, Monitoring, and Decontamination	Provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

Note:
RCA = radiologically controlled area

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel trowel or disposable plastic scoop is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling*.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight ("hammer") dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless-steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 *Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils* (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

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[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

Note 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

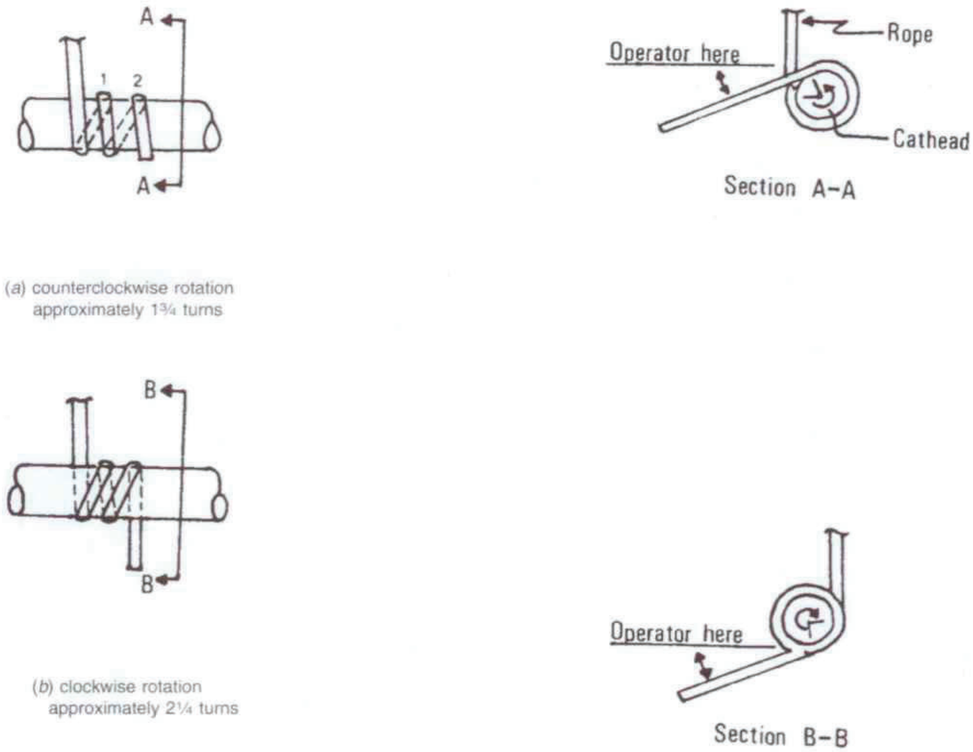


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

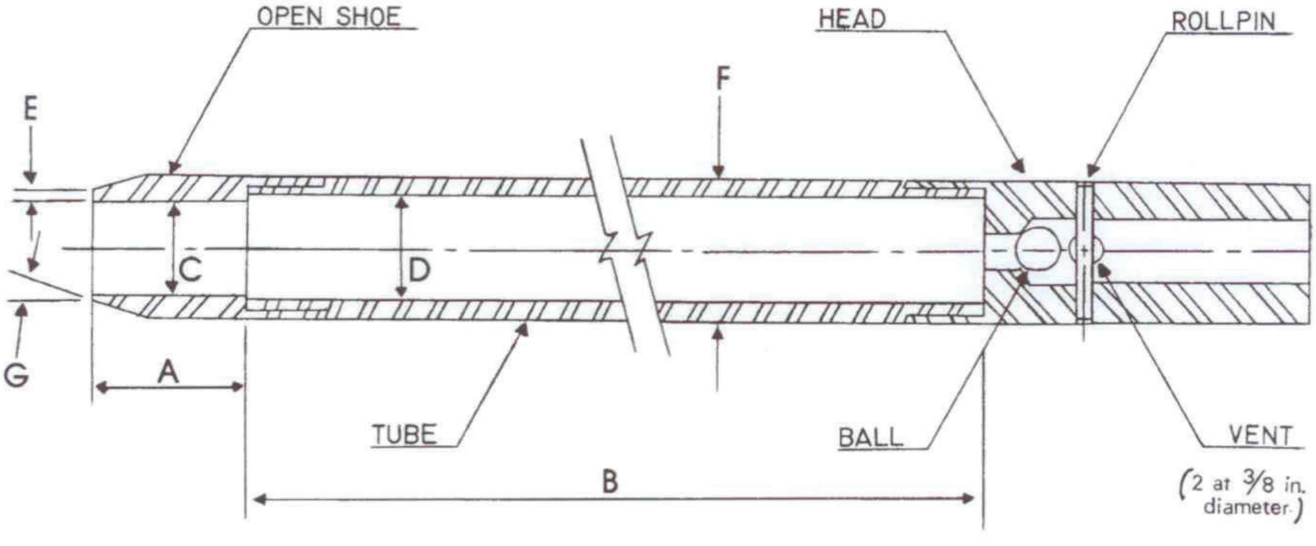
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

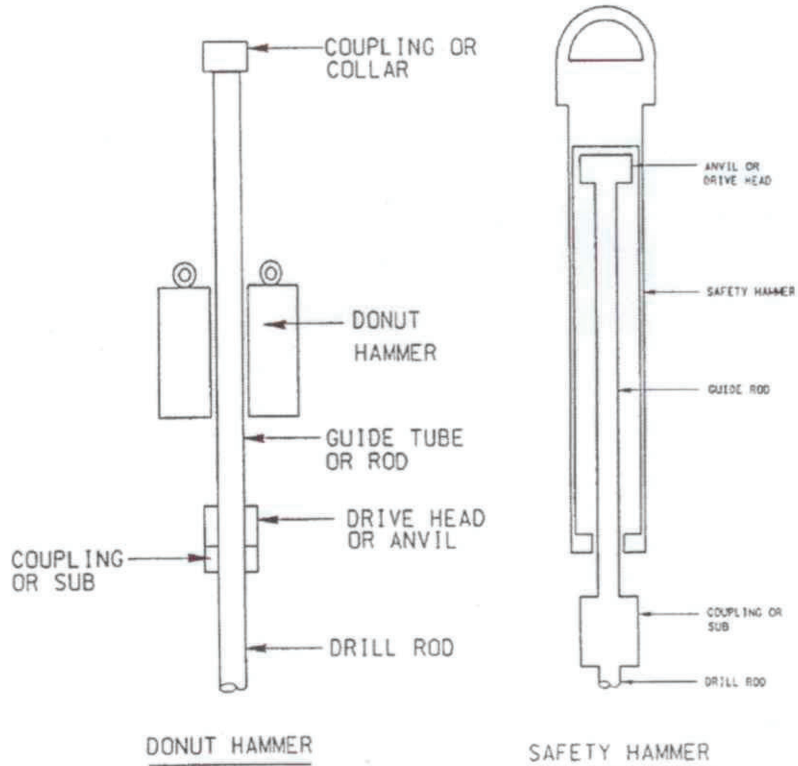


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

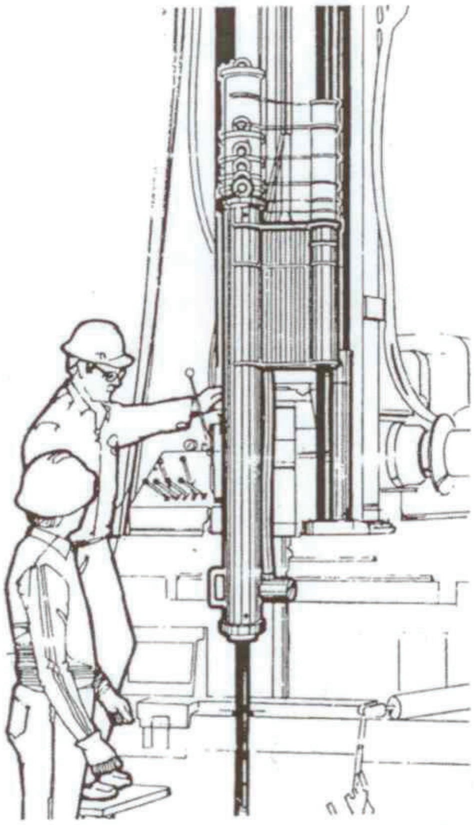


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (N) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "N-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the N-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop heights and Practice D 6066 provides information on adjustment of N-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in N-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project ______________________ **Project No** ______________________ **Boring No** ________

Location ______________________ Sheet ______ of ______

Date Started __________ **Date Completed** __________

Drill Crew:

Boring Location
Station __________ Offset __________

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type ______________________

Method Of Drilling:

Auger __________ Size __________

Wash ______ Water ______ Mud ______

Hammer Type

Auto __________ Manual __________

Split-Spoon Type

Length __________ Liner Used __________

Boring Size __________ Bit Used __________

Casing Size __________ Length __________

Weather ______________________

Non-Drilling Time (Hrs.)

Boring Layout ______ Moving ______

Hauling Water ______ Standby ______

Water Level @ ______ Date ______ Time ______

@ ______ Date ______ Time ______

@ ______ Date ______ Time ______

Cave-in Depth

@ ______ Date ______ Time ______

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.
(*2*) Scope was completely revised.
(*3*) Referenced Documents updated to include new standards.
(*4*) Terminology: added section on Definitions.
(*5*) Significance and Use: clarified use of the SPT test.
(*6*) Apparatus: general editorial changes.
(*7*) Sampling and Testing Procedure: general editorial changes.
(*8*) Data Sheets/Forms: general editorial changes.
(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

Designation: D 1587 – 00 (Reapproved 2007)$^{\epsilon 1}$

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ϵ^1 NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids
D 1452 Practice for Soil Investigation and Sampling by Auger Borings
D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils
D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

	Nominal Tube Diameters from Table 2[A] Tolerances					
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

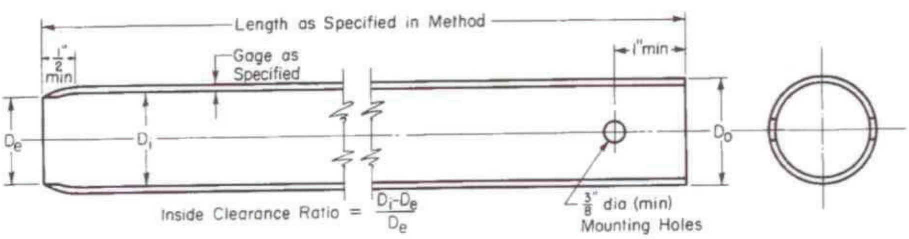
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
3/8	9.53
1/2	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

TABLE 2 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include:

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured,

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the soil boring log form (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for ASTM D1586 (attached), a standard soil boring log form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both sample jar labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as “approximate” or “estimated” as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, sonic). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil consistency of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch OD, and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch OD). A stiffer rod, such as an "N" rod (2-5/8-inch OD), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

Soil Boring Log Form with a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT ______________________ LOCATION ______________________

ELEVATION ______________ DRILLING CONTRACTOR ______________________

DRILLING METHOD AND EQUIPMENT ______________________

WATER LEVELS ______________ START ________ FINISH ________ LOGGER ________

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG,
FORM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
DEN 22371.G5	BL-3	SHEET 1 OF 3

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centennial, CO
ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado
DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig
WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A.Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0	2.5				Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5–4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
5	5.0–6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft; strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
	8.0–10.0	3-ST	1.3	———	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	10.0–11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730 Driller notes rough drilling action and chatter @ 13 ft
15	15.0–15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	Driller notes smoother, firm drilling @ 19 ft
20	20.0–21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot tip of 6-S, poss boulders or rock Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.0–23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

(47) MAY 12 2003 EXAMPLE

0715 ARRIVE ON SITE At XYZ SITE.
CH2M Hill STAFF:
John Smith: FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + Cool, 45°F
CHANCE of LATE Showers
SCOPE: • Collect GROUNDWATER
SAMPLES for LTM work at Site 14
• SUPERVISE SURVEY CREW
At Site 17
0725 BB ~~Cal~~ (JS) Calibrates
PID: 101 ppm/100 ppm ok
PID Model #, SERIAL #
0730 BB Calibrates HORIBA METER
Model #, SERIAL #
→ List calibration Results
0738 Survey CREW ARRIVES on Site
→ List NAMES
0745 BB Holds H+S TAlk on Slips,
Trips, FAlls, Ticks + AIR Monitoring
JS + Survey CREW ATTEND
No H+S ISSUES IDENTIFIED as
CONCERNS. All work is in "Level D."
0755 JS Conducts site-wide Air Monitoring
All readings = 0.0 ppm in

JS
5-12-03

MAY 12, 2003 EXAMPLE (48)

SITE 14 LTM
BREATHING ZONE (BZ)
0805 Mobilize to well MW-22 to
Sample, surveyors setting up
At Site 17
0815 PM (PAUL PAPER PUSHER) CAlls AND
INFORMS JS to collect GW SAMPLE
At well MW-44 today for 24 hour
TAT ANALYSIS OF VOC'S
0820 Purging MW-22
→ RECORD WATER QUALity DATA

JS
5-12-03

0843 Collect SAMPLE At MW-22 for
total TAL Metals AND VOC'S. No
Dissolved Metals Needed PER PM.
0905 JS + BB Mobilize to Site 17 to
Show surveyors wells to Survey.
0942 Mobilize to well MW-22 to
Collect SAMPLE...
0950 CAN not Access Well MW-22
due to BASE OPERATIONS; Contact
PAUL PAPER PUSHER AND he STATED
he will check on GAINING ACCESS
with BASE contact.
0955 Mobilize to well MW-19

JS
5-12-03

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

*A Summary of Changes section appears at the end of this standard.

limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve.

fine—passes a No. 40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

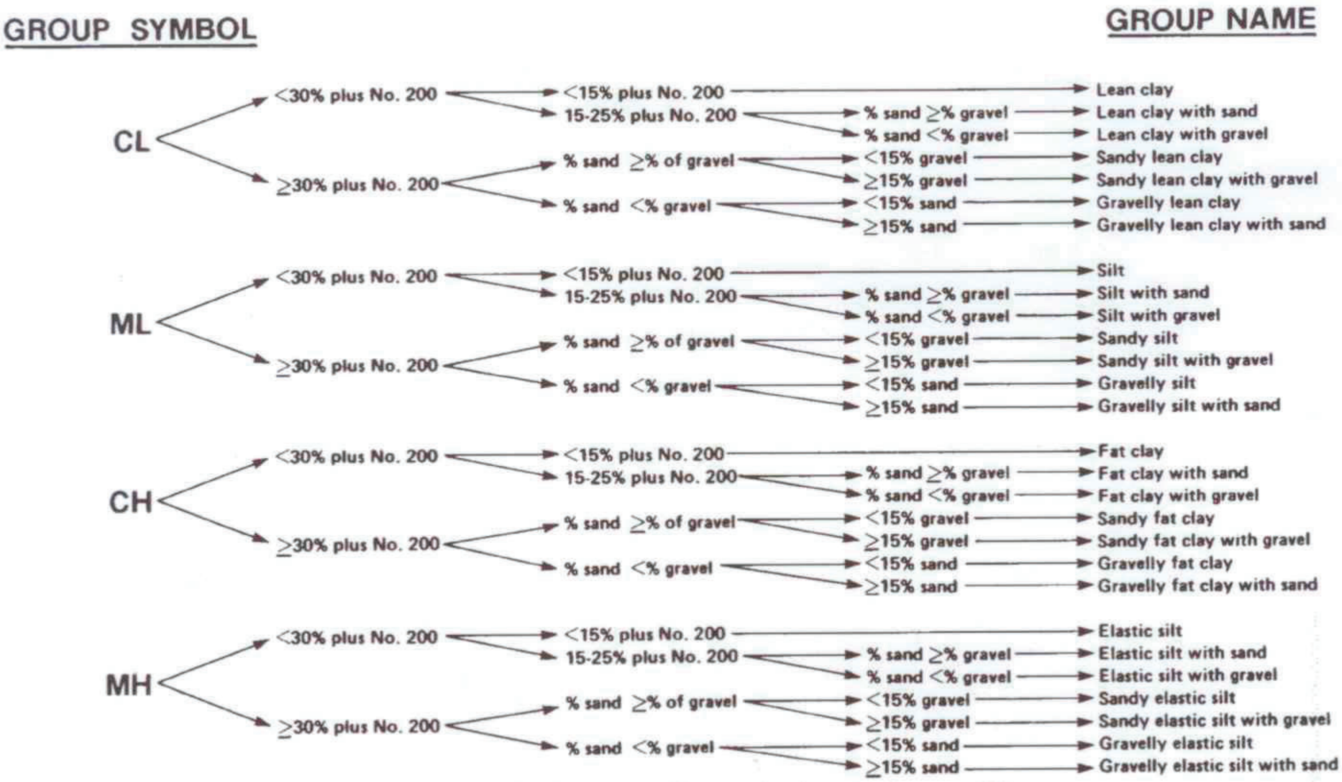
6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens*.

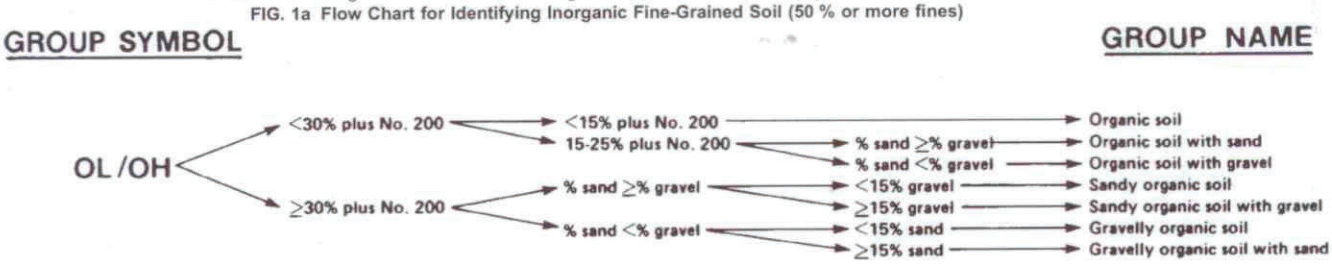
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

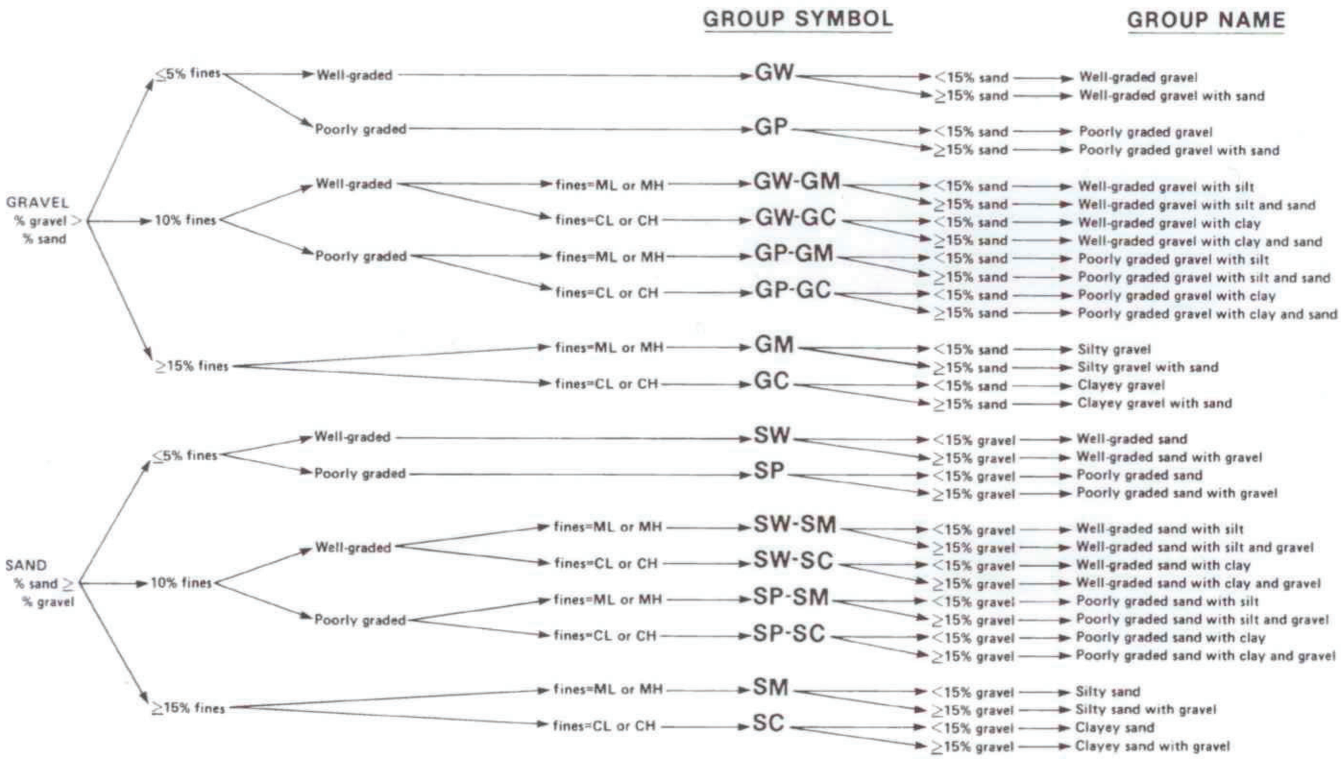
NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

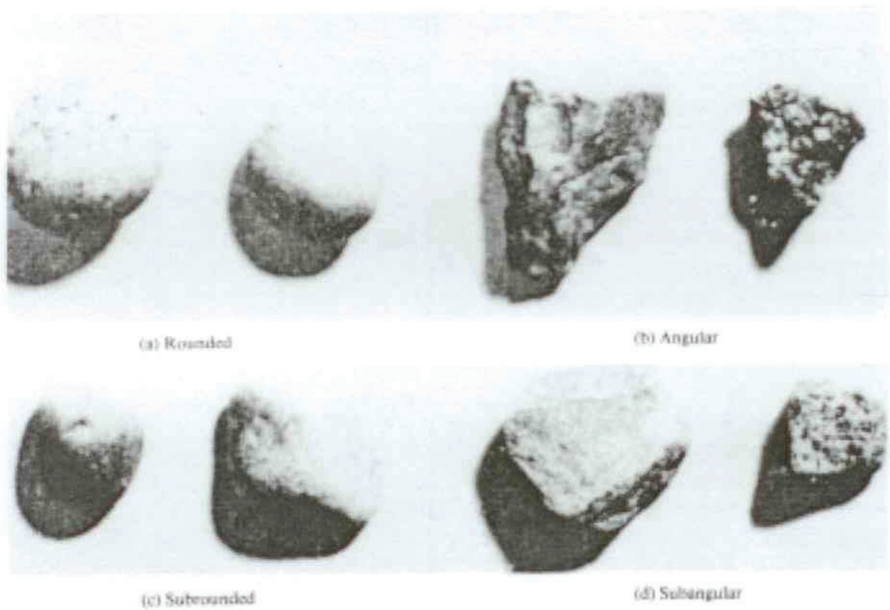


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

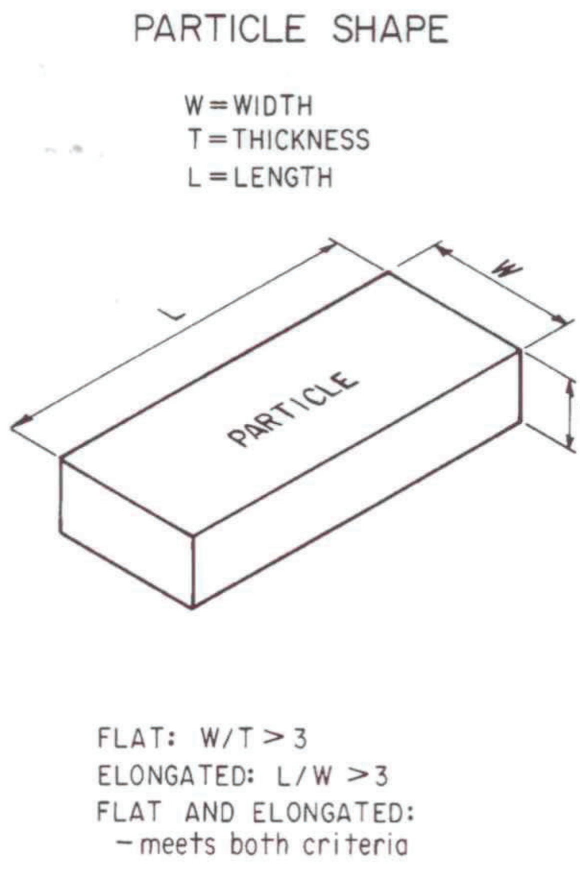


FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils
(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix: Suffix:

s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition ($1993^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

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[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

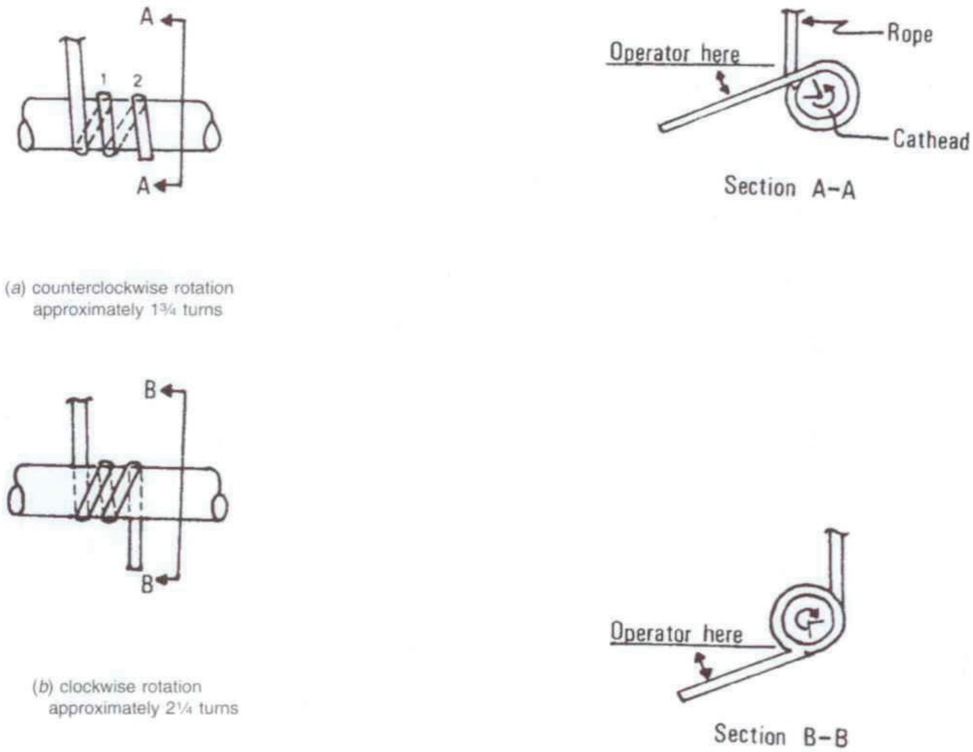
4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it



(a) counterclockwise rotation approximately 1¾ turns

(b) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (a) Counterclockwise Rotation and (b) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

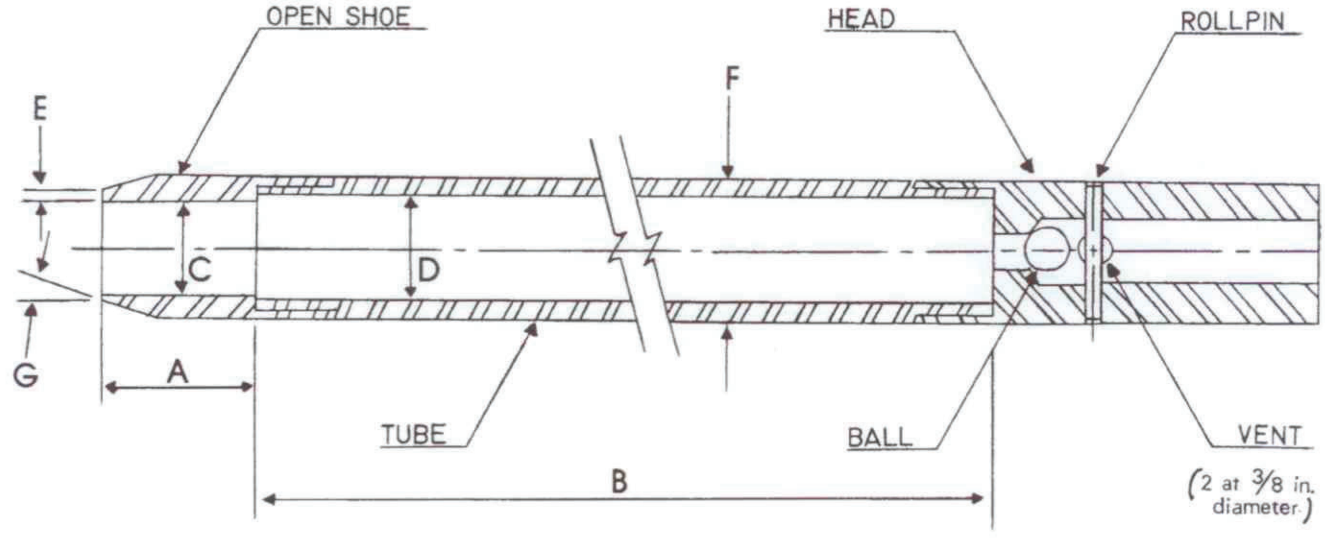
5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

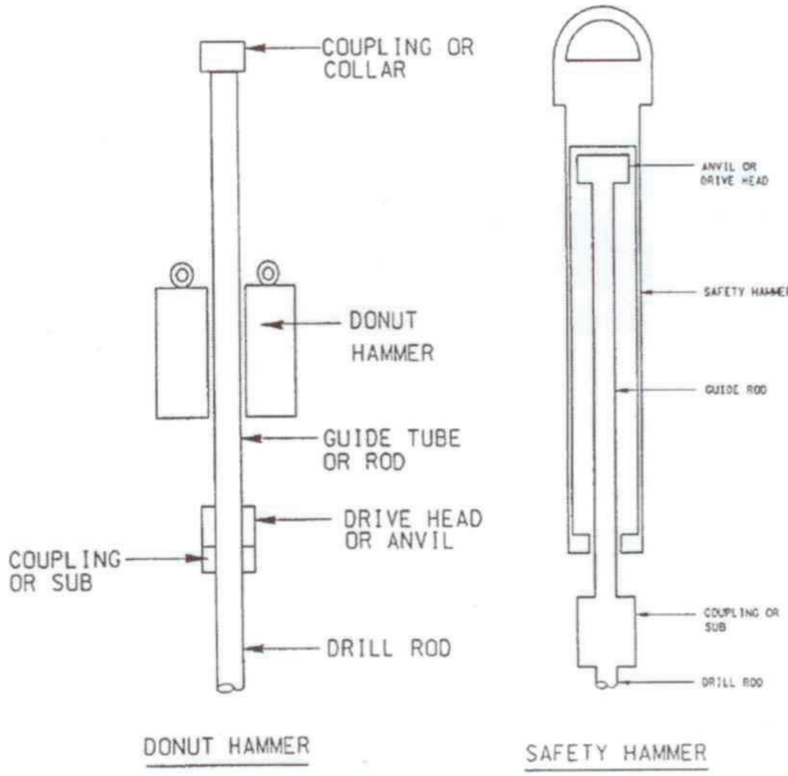


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

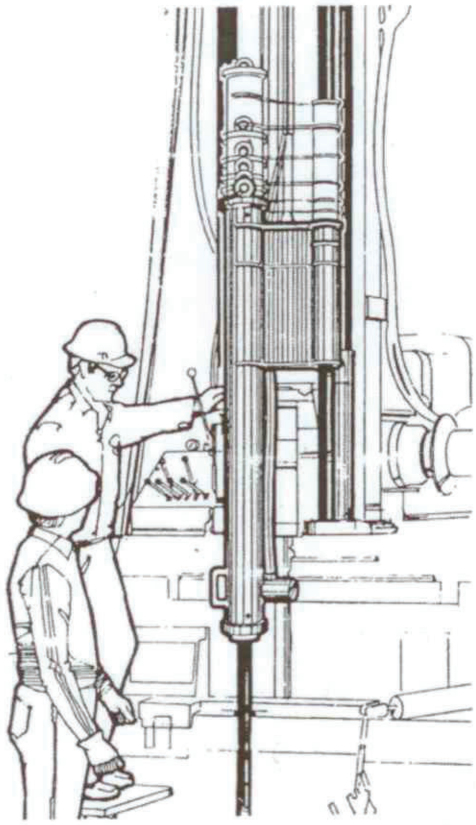


FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

DRILLERS BORING LOG

Project ______________________ Project No ______________________ Boring No ________

Location ______________________ Sheet ______ of ______

Date Started ____________ Date Completed ______________

Drill Crew:

Boring Location
Station __________ Offset __________

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type ______________________

Method Of Drilling:

Auger ____________ Size ______________

Wash ________ Water ________ Mud ________

Hammer Type

Auto ____________ Manual ____________

Split-Spoon Type

Length ____________ Liner Used ____________

Boring Size ____________ Bit Used ____________

Casing Size ____________ Length ____________

Weather ______________________

Non-Drilling Time (Hrs.)

Boring Layout ________ Moving ________

Hauling Water ________ Standby ________

Water Level @ ________ Date ________ Time ________

@ ________ Date ________ Time ________

@ ________ Date ________ Time ________

Cave-in Depth

@ ________ Date ________ Time ________

FIG. 5 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.

(*2*) Scope was completely revised.

(*3*) Referenced Documents updated to include new standards.

(*4*) Terminology: added section on Definitions.

(*5*) Significance and Use: clarified use of the SPT test.

(*6*) Apparatus: general editorial changes.

(*7*) Sampling and Testing Procedure: general editorial changes.

(*8*) Data Sheets/Forms: general editorial changes.

(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

SF032/010.50

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized (“DI”) water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)

6. Rinse with 1 gallon of tap water. (deionized water may be substituted for tap water)

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.
2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, Liquinox® solution (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for all of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Rite in the Rain® or Sanford Sharpie® permanent markers. **Note:** for sites where PFC is being analyzed for, Rite-in-the-Rain®, Sanford Sharpie®, or anything water-resistant or with Teflon® cannot be used in the field. All field book materials must be "fluorine free". Acceptable substitutes would be a sewn notebook without a plastic cover, or loose-leaf notebook paper.
2. On the inside cover of the log book the following information should be included:

- Company name and address
- Log-holders name if log book was assigned specifically to that person
- Activity or location
- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."
4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.
5. Daily entries will be made chronologically.
6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.
7. Each page of the log book will have the date of the work and the note takers initials.
8. The final page of each day's notes will include the note-takers signature as well as the date.
9. Only information relevant to the subject project will be added to the log book.
10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.
2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements

for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Draw a box around the sample ID so that it stands out in the field notes
    - Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
    - Parameters to be analyzed for, if appropriate
    - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).
2. Use tables to record sampling information and field data from multiple samples.
3. Sketch sampling locations and other pertinent information.
4. Sketch well construction diagrams.

V. Attachments

Example field notes.

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV. Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,
- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project – Name of project site.
- Sample Identification - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 05/21/17).

- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name or initials of the sampler.
- Remarks - Any pertinent additional information.

The field team should always follow the sample ID system prepared by the Project Chemist and reviewed by the Project Manager.

Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).
- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).
- Sign, date, and enter the time under "Relinquished by" entry.
- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used and enter the airbill number under "Remarks," in the bottom right corner;
- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.
- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.
- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

V Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VI Attachments

A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

Attachment A
Example Sample Label

QAL

Quality Analytical Laboratories, Inc.
2567 Fairlane Drive
Montgomery, Alabama 36116
PH. (334)271-2440

Client ______
Sample No. ______
Location ______

Analysis ______

Preservative HCL
Date ______ By ______

CEIMIC CORPORATION
10 Dean Knauss Drive, Narragansett, R.I. 02882 • (401) 782-8900

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE

SAMPLE TYPE

☐ Grab ☐ Composite ☐ Other ______

COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M HILL
APPLIED SCIENCES LABORATORY

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project #	Purchase Order #
Project Name	
Company Name CH2M HILL Office	
Project Manager & Phone # Mr. [ ] Ms. [ ] Dr. [ ]	Report Copy to:
Requested Completion Date:	Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____ — Sample Disposal: Dispose ☐ Return ☐

OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

SHADED AREA– FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page of
Login	LIMS Ver

Sampling Date	Sampling Time	Type: COMP	Type: GRAB	Matrix: WATER	Matrix: SOIL	Matrix: AIR	CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED	REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	QC Level: 1 2 3 Other: ____
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	COC Rec / ICE
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time	Ana Req / TEMP Cust Seal / Ph
Received By (Please sign and print name)	Date/Time	Shipped Via: UPS BUS Fed-Ex Hand Other ____	Shipping #	
Work Authorized By (Please sign and print name)	Remarks			

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: Original - LAB, Yellow - LAB, Pink - Client

REV 3/94 FORM 340

Attachment C
Example Custody Seal

CH2M HILL

CUSTODY SEAL

Date ______________________ ______________________

Signature ______________________ ______________________

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- Strapping tape
- Contractor bags
- Absorbent pads or equivalent
- Resealable bags
- Bubble bags (for glass bottle ware)
- Bubble wrap (if needed)
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with absorbent pads or similar material.
- Place a contractor bag inside the cooler.

B. Affix appropriate adhesive sample labels to each container. Protect with clear packing tape.

C. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks. Cross check CoC to ensure all samples are present.

D. Seal each glass sample bottle within a separate bubble bag (VOCs grouped per sample location). Sample labels should be visible through the bag. Whenever possible, group samples per location for all analytes and place in resealable bags. Make sure to release as much air as practicable from the bag before sealing.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in resealable bags and placed on and around the containers.

G. Fill remaining spaces with bubble wrap if needed.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear packing tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with clear packing tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Scan airbill receipt and CoC and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result, only employees who are trained under Jacobs Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated Jacobs HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

PERMA-FIX ENVIRONMENTAL SERVICES		
TITLE: **Radiation Protection Program**	**NO.:**	RP-100
	PAGE:	1 of 6
	DATE:	May 2013

APPROVED:

_____________________________ 5/31/13
Technical Services Manager Date

_____________________________ 5/31/13
Corporate Certified Health Physicist Date

1.0 PURPOSE

This administrative procedure describes the major elements of the Radiation Protection Program for Perma-Fix Environmental Services, Inc. (PESI). As applicable, this administrative procedure references sections in the Radiation Protection Plan and project procedures which describe the program in more detail.

2.0 APPLICABILITY

These program descriptions apply to personnel who plan, review, supervise, or perform work involving radiation protection activities during remediation.

3.0 REFERENCES

References are listed in the specific Project Procedures that comprise this Radiation Protection Program.

4.0 DEFINITIONS

Radiation Work Permit (RWP): A document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions that exist in the work area and the radiological requirements for the job.

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and byproduct material procured and used to support the operation or remediation.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO advises project management on all aspects of Radiation Protection and Operational Health Physics. The RSO directs all radiological safety activities on the project. The RSO has the authority to suspend operations and / or restrict personnel access at the project as a result of nonconformance to this SSHP, or other applicable regulations, and when radiological conditions change beyond the scope of an HWP. The RSO is responsible for:

- Implementing and ensuring compliance with RPP's policies and procedures.
- Inspect work activities to ensure operations, including off-normal activities, are being conducted according to the facility or project requirements, applicable federal regulations, and industry accepted As-Low-As-Reasonably-Achievable (ALARA) principles.
- Reviewing and approving work plans, Radiation Work Permits, and RPP procedures.
- Trending radiation work performance of project personnel including contamination and radiation exposure control.
- Identifying, reviewing, and documenting nonconformance, their causes and corrective actions for incidents associated with radiation protection.
- Ensuring an effective ALARA Program including conducting onsite radiation safety and health briefings.
- Ensuring documentation of any RPP safety violation.
- Reviewing survey data.
- Conducting briefings concerning radiological work activities.
- Ensuring that radiological records are complete, clear and legible, meet the intended purpose, and are regularly transmitted to document control for archive.
- Ensuring Restricted Areas are correctly identified, posted and marked.
- Performing or coordinating regular internal audits of the RPP.

5.2 Radiation Protection Technicians (RPTs)

RPTs report directly to the RSO. RPTs are assigned by the RSO to provide support to each major field activity for implementation of RPP requirements. RPTs provide guidance in RPP matters to field personnel. RPTs have stop-work authority for radiological safety matters and activities that could result in an unsafe condition being present. RPTs are responsible for the following:

- Conducting routine and job-specific radiological surveys (i.e., radiation, contamination, and airborne radioactivity).
- Establishing radiological postings.
- Implementing the personal protective equipment (PPE) and respiratory protection programs for the purpose of keeping radiation exposures ALARA.

- Maintaining and operating portable Health Physics survey instrumentation used in the performance of Radiation Protection (RP) activities.
- Performing unconditional release surveys of material from the restricted area.
- Performing transportation radiological surveys according to applicable U.S. Department of Transportation (DOT) regulations.
- Assisting the SSHO with IH&S monitoring and inspections to a level commensurate with training and experience.

5.3 Project Supervisors

All Project Supervisors are responsible for:

- Ensuring personnel under their direction comply with RPP requirements.
- Providing information on projected work activities to the RPP organization.
- Notifying RP personnel of any radiological problems encountered.
- Ensuring workers are prepared for tasks with tools, equipment and training to minimize time spent in radiological areas.

5.4 Project Radiation Workers

All Project Radiation Workers and individuals entering radiologically controlled areas are responsible for:

- Obeying promptly “stop-work” and “evacuate” orders from RP personnel and the SSHO.
- Obeying posted, oral and written radiological control instructions and procedures, including instructions on Radiation Work Permits and those in the SSHP.
- Immediately reporting lost dosimetry devices to RP personnel.
- Reporting medical radiation treatments to the RSO and supervisor.
- Keeping tack of personal radiation exposure status to ensure that administrative dose limits are not exceeded.
- Notifying RP personnel of faulty or alarming radiation protection equipment, and unsafe radiological conditions.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

None

8.0 APPARATUS

None

9.0 RECORDS

None

10.0 PROCEDURE

10.1 Radiation Protection Organization

1. The RPP Organization will provide appropriate personnel and resources to verify and maintain a radiologically safe working environment.
2. RPP staffing levels will be periodically reviewed to ensure that adequate staffing levels are maintained consistent with current and planned remediation activities.
3. The Project RPP Organization will have access to engineering and other personnel needed to support the Radiation Protection Program.
4. The development and control of RPP Project Procedures will be in accordance with the following guidelines:
   - Clearly defined scope, tasks, applicability, limiting conditions, precautions, consideration of special controls, reference to acceptance criteria and quality requirements.
   - Clearly understood text, using standard grammar, nomenclature and punctuation, concise instruction steps in a logical sequence, and references.
   - Review, approval, issuance, and control of changes and permanent revisions.

10.2 ALARA Program

All activities involving radiation and radioactive materials shall be conducted in such a manner that radiation exposure to workers and the general public are maintained As-Low-As-Reasonably-Achievable (ALARA), taking into account current technology and the economics of radiation exposure reduction in relationship to the benefits of health and safety. ALARA concepts are implemented throughout the entire RPP. ALARA-program requirements include:

1. Administrative controls and procedures endeavor to reduce individual and collective radiation exposures ALARA. Minimizing radiation exposure is accomplished by preliminary planning and scheduling, using proven and innovative engineering techniques and performing engineering reviews of proposed work plan changes.
2. Worker involvement and acceptance in minimizing radiation exposure is a key component of the ALARA Program. Workers are responsible to incorporate ALARA principles into work performance.
3. Work shall be planned in accordance with ALARA principles, involving input from discipline engineers, the project RPP staff and implementing supervisors.
4. An Embryo-Fetus Protection Program has been established for the Project and is specified in RPP-113, “Embryo-Fetus Protection”

10.3 Radiation Protection Audit Program

1. Internal / External Audits of the Radiation Protection Program should be performed, documented, and be of sufficient scope, depth, and frequency to

identify and resolve actual or potential performance deficiencies before significant quality problems are encountered. Audit frequency and criteria is determined by the RSO and / or SSHO.

2. The RSO and / or SSHO shall perform an annual review of RPP content and implementation as specified in 10 CFR 20.1101(c).

10.4 External and Internal Dosimetry Program

Internal and external dosimetry and exposure control requirements are defined in the PESI Radiation Protection Plan and includes:

- A discussion of applicable regulatory limits for occupational workers and members of the public.
- ALARA goals.
- Monitoring requirements.
- Recordkeeping requirements.
- Reporting requirements for both normal operations and incidents.

10.5 Radiation Protection Instrumentation Program

All instrumentation used to measure radiation and radioactive material will be maintained in accordance with their respective technical manuals and operating procedures This includes establishing criteria and requirements for the operation, calibration, response testing, maintenance, inventory and control of radiation protection instrumentation and equipment to comply with applicable regulations and conform with applicable ANSI standards. The Instrumentation Program is detailed by specific procedures including RP-108, RP-109, and RP-110.

10.6 Access Control Program

Access controls to radiological areas will be maintained at all times at the PESI. The administrative and physical measures used to control access to Restricted and/or Radiological Areas are established procedures RP-101, RP-102, and RP-103

10.7 Radiation Protection Surveillance Program

The Radiation Protection Surveillance Program provides for the conduct of radiological surveys in all areas controlled for the purpose of radiation and/or radioactivity. The Program encompasses both routine and non-routine surveys to be performed within the PESI. The specific requirements for conducting and documenting radiological surveys at the PESI are detailed in procedures RP-104, RP-105, RP-106, and RP-107

10.8 Radioactive Material Control Program

This Program provides guidance and requirements for control of radioactive materials. The Radioactive Material Control Program includes receipt, inventory, handling, and release of materials. It also provides for radioactive sealed source control, control of materials entering Restricted Areas and control of contaminated tools and equipment. The requirements of this program are established in RP-111

10.9 Respiratory Protection Program

It is not expected that respirators will be widely used by PESI staff for radiation protection purposes at PESI. As such the Respiratory Protection Program will be administered by the SSHO in accordance with the PESI Site Safety and Health Plan. The SSHO will consult with the RSO when respiratory protection is required for radiological purposes.

10.10 Radiological Training

The Radiological Training is required for PESI employees and/or subcontractors who perform work near, or in areas controlled for the purpose of radiation and/or radioactive materials as defined in Section 8.1 of the PESI Radiation Protection Plan. There are two basic levels of training: General Employee Radiation Training for visitors and non-radiation workers, Radiation Worker Training for workers who access Restricted Areas.

10.11 Radiation Protection Records

Radiation Protection Records are routinely developed to document all aspects of the Radiation Protection Program. Records are generated using clear concise text using standard grammar and punctuation. Records are reviewed for adequacy and completeness and transmitted to the Document Control organization for long-term retention.

PERMA-FIX ENVIRONMENTAL SERVICES		
TITLE: **Access Control**	**NO.:**	RP-101
	PAGE:	1 of 6
	DATE:	May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for controlling the access of personnel, equipment, and vehicles into radiological areas.

2.0 APPLICABILITY

This procedure applies to all Project personnel and visitors, equipment, and vehicles entering Restricted Areas.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions and Reports to Workers Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RPP-102, "Radiological Posting Requirements."
5. RPP-103, "Radiation Work Permits Preparation and Use."
6. 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response."

4.0 GENERAL

4.1 Discussion

Access controls are used to ensure the radiological safety of personnel entering into Restricted Areas. These controls include, but are not limited to Training, Dosimetry, Posting, Area Monitoring, and Radiation Work Permits (RWP).

4.2 Definitions

ALARA: Means as low as reasonably achievable.

GET: General Employee Training

GERT: General Employee Radiation Training

HAZWOPER: 40-Hour Hazardous Waste Operations and Emergency Response training in accordance with 29 CFR 1910.120

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas. **RPT:** Radiation Protection Technician

Radiation Work Permit (RWP): A document or series of documents prepared by the Radiation Protection Group to inform workers of the radiological, industrial hygiene and other safety conditions which exist in the work area and task-related radiological and other safety requirements.

RSO: Radiation Safety Officer

SSHO: Site Safety and Health Officer

SRD: Self-Reading Dosimeter

Visitor: An individual who accesses the project site for purposes other than for assignment as a Project Worker (e.g., site visit, performance of an essential short-term task).

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring that all activities performed within this procedure conform to the requirements of the PESI Site Safety & Health Plan (SSHP).
- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.2 Radiation Safety Officer (RSO)

- Implementing this procedure.
- Approving RWPs to control access to Restricted Areas.
- Reviewing and approving training programs related to work in Restricted Areas.
- Implementing the requirements of the PESI Radiological Protection Program.
- Providing direction to the Project Personnel regarding radiological matters.

- Authorizing escorted visitor entries into Restricted Areas. This responsibility may be designated.
- Evaluating visitor entries to Restricted Areas to minimize or eliminate exposure risk to personnel who lack adequate training.

5.3 Radiation Protection Technician (RPT)

- Identifying and posting Restricted Areas.
- Providing RWP briefings to individuals entering Restricted Areas.
- Conducting radiation and contamination surveys, and keeping legible records.
- Monitoring work activities to ensure compliance with the requirements of the Radiological Protection Program.

5.4 Project Supervisor

- Ensuring that personnel assigned to work in Restricted Areas or with radioactive material, attend required training and perform work in a radiologically sound and safe manner.
- Contacting the RSO or designee, to obtain approval to bring escorted visitors into Restricted Areas.
- Notifying the RSO or designee, in advance (when possible) of the need to bring any non-project owned equipment / vehicles into the Restricted Area to arrange for baseline contamination surveys.

5.5 Project Personnel

- Attending designated training classes.
- Following directions from the RPT with regards to Safety and Health.
- Maintaining their personnel exposures ALARA.
- Limiting the amount of material taken into Restricted Areas to that necessary for task performance.
- Working in a manner so as to prevent spread of contamination and reduce airborne radiological emissions to the extent possible.

6.0 PREREQUISITES

6.1 Individuals requiring unescorted access into a Restricted Area shall submit the following documentation to the RSO **prior** to entry:

- Evidence of initial 40-Hour and 8-Hour Refresher OSHA HAZWOPER Training (if applicable)
- Current medical examination performed within the past 12 months.
- Evidence of successful completion of Site Orientation Training (GET/GERT) and Radiation Worker Training (RWT).

6.2 Individuals requiring unescorted access into a Restricted Area shall meet the requirements for Restricted Area access and have the following at a minimum:

- Thermoluminescence Dosimeter (TLD) or Self-Reading Dosimeter (SRD).
- Personal Protective Equipment (PPE) specified by posting and/or RWP.

6.3 Visitor access into Restricted Areas is limited to essential tasks which meet all of the following requirements:

- The task cannot be performed by appropriately trained Project Personnel
- The task is time critical in nature and would have a negative impact on safety & health or project operations if not performed.
- The task cannot be deferred until the Restricted Area is remediated or down posted.

7.0 PRECAUTIONS AND LIMITATIONS

- No unessential visitors shall be allowed access to the restricted areas.
- Visitors shall receive visitor specific site orientation training prior to accessing a restricted area. Training shall be documented.
- Personnel, equipment, and vehicle entry control shall be maintained for each radiological area.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.
- Trained emergency response personnel (Fire Dept., Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Any member of the public exposed to radiation and / or radioactive material shall not exceed 0.1 rem Total Effective Dose Equivalent per year.
- All visitors entering into a Restricted Area shall be escorted at all times by a qualified radiation worker. The RSO and SSHO or designee(s) shall approve these entries. The escort is responsible for visitor compliance with site protocols.
- Visitors may not enter a posted High Contamination Area, Radiation Area, High Radiation Area, or Airborne Radioactivity Area.
- Visitors shall not perform any work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or an abrasive nature (i.e., welding, sanding, grinding, etc.) in Controlled Areas unless evaluated and approved by the RSO or designee.
- Visitors may only enter those areas where hazardous atmospheres do not exceed 50% of the Permissible Exposure Limit and where radiation exposures would not exceed the annual dose limit to a member of the public as specified in 10 CFR 20.
- The RSO shall ensure that risk of exposure to hazardous materials is minimized or eliminated prior to authorizing visitor entry into Restricted Areas. No work of an intrusive nature that may produce radioactive airborne particulates shall take place during visitor access to a restricted area.
- Visitors shall not be allowed to come into contact with tools, vehicles or materials that are contaminated above the release levels established in the SSHP.
- Project personnel who are required to escort individuals into a Restricted Area shall have successfully completed Radiation Worker Training (RWT), which includes training on the requirements of this procedure, and have a demonstrated knowledge of the site layout, site history, and emergency response protocols.

- Project personnel who are required to escort individuals into a Restricted Area shall ensure the visitors complete the “PESI Visitor Access Control Form” (see Attachment 1).
- RPTs shall perform exit frisking of visitors from Restricted Areas when frisking is required by RWP. Visitor access times and dates, PPE, controls and conditions shall be documented.

8.0 APPARATUS

None

9.0 RECORDS

- PESI Visitor Access Control Form
- RWP Access Registers are maintained under separate procedure.
- Quality Records generated under this procedure submitted to Document Control.

10.0 PROCEDURE

10.1 Restricted Areas

1. Enter the Restricted Area **ONLY** through the designated Access Control Point unless instructed otherwise by the RPT.
2. Inform the Access Control Point RPT of the nature of your work in the Restricted Area. Provide details as requested by the RPT.
3. Adhere to the requirements of Section 10.2 of this procedure if taking equipment or vehicles into the Restricted Area.
4. Review the applicable RWP and assemble and dress in the appropriate PPE.
5. Sign-in on the RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of access.
6. Conduct all activities in a safe manner while working in the Restricted Area. Adhere to established safety and housekeeping protocols.
7. Exit the Restricted Area **ONLY** through the Access Control Point unless instructed otherwise by the RPT. Perform an exit frisk as required by RWP.
8. Sign-out on the appropriate RWP Access Register. Signatures must be clear and legible, and must be accompanied by time of egress.

10.2 Equipment and Vehicles Entering and Exiting Restricted Areas

1. Notify the RPT of any equipment / vehicles that need to be taken into a Restricted Area. Incoming surveys are performed on equipment and materials entering Restricted Areas. The purpose is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The decision regarding what must be surveyed will be made by the RSO. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.
2. Bring only the required equipment / supplies necessary for the task into the Restricted Area.

3. When practicable, use contamination prevention methods such as wrapping or sleeving of equipment taken into a CA or ARA.
4. Remove as much packaging material as possible (i.e., plastic or cardboard) prior to entering a Restricted Area.
5. Notify the RPT of any equipment / vehicles that need to be removed from a Restricted Area.

10.3 Visitor Escorts

1. Discuss planned activities, work locations, and site hazards with the Visitor. Discuss any restrictions on where the Visitor may go and what the Visitor may do within the Restricted Areas. Define the obligations of the Visitor with respect to following instructions of the escort and of safety personnel.
2. Provide the Visitor with a copy of the PESI Visitor Access Control Form (Attachment 1).
3. Instruct the Visitor to review the form, complete the top portion, and sign.
4. Answer any questions the Visitor may have. RP personnel are available to answer questions as needed.
5. Sign the PESI Visitor Access Control Form acknowledging escort responsibilities.
6. Obtain RSO and SSHO signature permitting Restricted Area access.
7. Give completed form to RP Personnel.
8. RP Personnel should assign a personnel dosimeter to the Visitor or group of visitors (this is a TLD unless otherwise instructed by the RSO). Note Self-Reading Dosimeter (SRD) in/out readings, if used, on the RWP Access Register.
9. Review the appropriate RWP with the Visitor, and ensure the Visitor dons PPE and signs and records the time of entry onto the RWP Access Register.
10. Escort the Visitor into the Restricted Area observing all escort responsibilities.
11. Upon completion of activities, assist visitor with PPE removal, and RWP sign-out. An RPT will perform the exit frisking.
12. Escort the Visitor out of the Restricted Area.
13. Take the personnel dosimeter and give it to the RP personnel. RP Personnel shall notify the RSO immediately if SRD readings indicate a personnel exposure.

11.0 ATTACHMENT

Attachment 1 PESI Visitor Access Control Form (FRONT & BACK)

ATTACHMENT 1

PESI VISITOR ACCESS CONTROL FORM (FRONT)

Name ______________________________ Representing ____________________________________

SSN _____ -_____ - _______ Mailing Address____________________________________ _____________

Some work at the PESI involves exposure to hazardous environments, radiation or radioactive materials. In keeping with the provisions of the Code of Federal Regulations Title 10, Part 19, this is to inform you of the extent of the hazards to which you may be exposed.

Radiation and radioactive materials on this project site are confined within clearly posted and delineated areas. Other hazardous materials may be present in these areas. Signs in these areas are magenta or purple and yellow in color and contain the international symbol for radiation, a trefoil or **three-bladed design. (ESCORT: SHOW VISITOR AN EXAMPLE OF A RADIOLOGICAL POSTING)**.

During your visit, you will be provided with an escort. You must remain with your escort at all times. In the unlikely event of an incident involving radioactive or other hazardous materials, your escort will provide you with instructions. Comply with the instructions of your escort. If exit frisking is required by the RWP, Radiation Protection Personnel will perform the exit frisk.

Do not enter any areas posted “RADIATION AREA” “HIGH CONTAMINATION AREA” or “AIRBORNE RADIOACTIVITY AREA.”

Do not perform work of an intrusive nature (i.e., digging, drilling, sampling, etc.) or any abrasive work (i.e., welding, sanding, grinding, etc.) without specific written approval of the RSO.

Nuclear Regulatory Guide 8.13, “Instructions Concerning Pre-natal Radiation Exposure” is available for review upon request.

Address any questions you may have to your escort or to the person you are visiting. Questions may also be directed to the Safety & Health Department.

I have read and understand the above. I agree to comply with the terms of this form.

Visitor Signature **Date**

I have reviewed the above with the visitor and agree to comply in full with PESI established radiological escort protocols including, but not limited to, those specific requirements specified on the back of this form.

Escort Signature **Date**

Restricted Area Access Authorized:

RSO or designee Signature **Date**

SSHO or designee Signature **Date**

ALL SIGNATURES MUST BE PRESENT ON THIS FORM PRIOR TO RESTRICTED AREA ACCESS!

ATTACHMENT 1 (BACK OF FORM)
PESI VISITOR ACCESS CONTROL FORM

SSHO/RSO Requirements to Minimize or Eliminate Exposure Risks:

SSHO/RSO Remarks:

SSHO Initials: __________ RSO Initials: ____________

	PERMA-FIX ENVIRONMENTAL SERVICES

TITLE:	**Radiological Postings**	**NO.:**	RP-102
		PAGE:	1 of 6
		DATE:	May 2014

APPROVED:

_________________________ 5/31/14
Technical Services Manager Date

_________________________ 5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for posting requirements for various radiological hazard areas on PESI Projects.

2.0 APPLICABILITY

This procedure applies to all which require radiological postings.

3.0 REFERENCES

1. 10 CFR 19, "Notices, Instructions, and Reports to Workers; Inspection."
2. 10 CFR 20, "Standards for Protection Against Radiation."
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)

4.0 GENERAL

4.1 Discussion

Radiological postings are used to delineate areas containing radiological hazards and to inform personnel of hazards. In addition, supplemental or informational postings may be included which provide personnel with entry requirements or protective equipment requirements. Barriers may be used in conjunction with postings to ensure that personnel do not inadvertently enter into an area with a radiological hazard. Barriers at the PESI and the vicinity properties are normally composed of rope, tape, or fencing.

4.2 Definitions

Posting: A standardized sign or label which bears the standard trefoil radiation symbol in magenta or black on a yellow background and information concerning a specific radiological hazard.

5.0 RESPONSIBILITIES

5.1 Site Safety & Health Officer (SSHO)

- The SSHO is responsible for ensuring all activities performed within this procedure conform to the requirements of the SSHP.

5.2 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Reviewing pertinent survey data and making periodic tours to verify all areas within the PESI are properly posted.
- Authorizing the de-posting or down-posting of areas.
- Providing technical direction to the Radiation Protection Technicians (RPTs).

5.3 Radiation Protection Technician (RPT)

- Directing the placement of radiological postings and barriers.
- Performing periodic radiation / contamination surveys to ensure radiological conditions have not changed.

5.4 Project Supervisor

- Ensuring that personnel working in their particular area obey all radiological postings.

5.5 Project Personnel

- Obeying all radiological postings.
- Following directions from the RPT with regards to radiological postings.
- Maintaining their personnel exposures as low as reasonably achievable (ALARA).

6.0 PREREQUISITES

RPTs will be trained to assess and recognize the various radiological hazards present at the PESI.

7.0 PRECAUTIONS AND LIMITATIONS

- Barriers and other means shall be used as required to maintain control of areas requiring posting.
- At a minimum, all access / egress points to areas requiring radiological posting shall be conspicuously posted with the appropriate signs which includes area descriptions and specific requirements for entry.
- Appropriate signs should be placed approximately every 40 feet around the perimeter of a posted area. At least one sign should be placed on each side of an area's boundary, visible from any normal avenue of approach. These signs require only area identifiers (e.g., Restricted Area, Radioactive Materials Area, Radiation Area, etc.) in addition to the standard "Caution" or "Warning" and the tre-foil.
- An RPT with the appropriate field survey instrumentation may serve as the radiological posting in situations where the task is of a short duration or at the discretion of the RSO.
- No radiological control(s) shall be installed in any area that would prevent the rapid evacuation of personnel in an emergency situation.

- Trained emergency response personnel (Fire Dept, Ambulance / EMT, Law Enforcement) responding to on-site emergencies are exempt from the requirements of this procedure.
- Postings should be as clear and concise as possible to prevent confusion on the part of personnel desiring to enter an area.
- Postings should not be hung from ladders, electrical wire, switches, vehicles, or any other item that could be damaged, moved, or could cause injury to personnel.
- If more than one level of radiological posting is required in an area, posting for each unique condition shall be identified starting with the highest hazard potential. However, it is not required to post areas with area identifiers that are superceded by postings identifying a higher hazard potential (e.g., posting a Contamination Area as a Radioactive Materials Area, etc.).
- Radiological postings shall not be moved or altered without approval from the RSO or the RPT covering the work.

8.0 APPARATUS

- Yellow and magenta barrier supplies (e.g., rad-rope, rad-tape, rad-ribbon, etc.)
- Signs and inserts as required
- Radioactive Material Labels or tags
- Stands or Stanchions

9.0 RECORDS

All surveys performed for radiological posting placement will be forwarded to project document control.

10.0 PROCEDURE

10.1 Controlled Areas

All access points to areas meeting the definition of a Controlled Area shall be posted with the words “CONTROLLED AREA,” or “US GOVERNMENT PROPERTY” plus any additional verbiage deemed appropriate by Project Management.

10.2 Restricted Areas

All access points to areas meeting the definition of a Restricted Area shall be posted with the words “RESTRICTED AREA.”

10.3 Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

10.4 High Contamination Areas

All access points to areas meeting the definition of a Contamination Area shall be posted with the words “CAUTION, HIGH CONTAMINATION AREA,” and with the words “RESTRICTED AREA,” as well as any special instructions deemed necessary by the RSO.

10.5 Radiation Areas

All access points to areas meeting the definition of a Radiation Area shall be posted with the words “CAUTION, RADIATION AREA” as well as any special instructions deemed necessary by the RSO.

10.6 High Radiation Areas

All access points to areas meeting the definition of a High Radiation Area shall be posted with the words “DANGER, HIGH RADIATION AREA” as well as any special instructions deemed necessary by the RSO.

10.7 Radioactive Materials Areas

All access points to areas meeting the definition of a Radioactive Materials Area shall be posted with the words “CAUTION, RADIOACTIVE MATERIALS AREA” as well as any special instructions deemed necessary by the RSO.

10.8 Airborne Radioactivity Area

All access points to areas meeting the definition of an Airborne Radioactivity Area shall be posted with the words “CAUTION, AIRBORNE RADIOACTIVITY AREA” as well as any special instructions deemed necessary by the RSO.

10.9 Posting / De-Posting / Down-Posting

Posting, De-posting, and Down-posting activities should be noted in the appropriate technician logbook with reference to applicable survey number(s).

11.0 ATTACHMENTS

None

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE:	Radiation Work Permits Preparation and Use	NO.:	RP-103
		PAGE:	1 of 7
		DATE:	May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure describes the conditions under which a Radiation Work Permit (RWP) is required on PESI Projects. This procedure establishes consistent methodology and responsibilities for developing, utilizing and terminating an RWP. The procedure also describes the functions of the RWP (a sample is given in Attachment 1).

2.0 APPLICABILITY

This procedure applies to RWP requests, preparation, use, and termination. All personnel working on a task for which a RWP is required are required to comply with its conditions.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Section 30255, "Notices, Instructions and Reports to Workers, Inspections, and Investigations."
2. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
3. RP-101, "Access Control."

4.0 DEFINITIONS

Airborne Radioactivity Area: Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values identified in Section 6.0 of the Radiation Protection Plan; and as listed in 10 CFR 20, Appendix B, Table I, Column 3

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in the United States Army Corps of Engineers (USACE) Radiation Protection Manual, "Acceptable Surface Contamination Levels," (also refer to Table 1 of the Radiation Protection Plan; and procedure RPP-104, "Radiological Surveys,") or any additional area specified by the Radiation Safety Officer (RSO). The

Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate exceeds 5 mrem/hr but less than 100 mrem/hr at 30 cm from the source.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

High Radiation Area (HRA): Means any area accessible to personnel where the whole body dose rate exceeds 100 mrem/hr at 30 cm (12 inches) from the radiation source.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: Means any area to which access is limited by Project Management for the purpose of protecting individuals against exposure to radiation and radioactive materials.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Approving all protective measures incorporated into the RWP with regards to Radiological Safety.

5.2 Radiation Protection Technician (RPT)

- Conducting radiation and contamination surveys and keeping legible records.
- Preparing RWPs to control access to and activities in radiological areas.
- Monitoring worker compliance with RWP requirements.

5.3 Project Personnel

- Reviewing the correct RWP for the task to be performed.
- Accurately and legibly completing required information on the RWP Access Register.
- Observing radiological postings.
- Obeying oral and written radiological and industrial hygiene control instructions and procedures, including instructions on RWPs.
- Maintaining an awareness of radiological and industrial hygiene conditions in the work area.

6.0 PREREQUISITES

1. A RWP shall be required for the following:
    - All tasks requiring entries into Radiological Areas.

- As specified by the RSO or their designees.

2. Prior to use of an RWP, the RSO or designee shall:
   - Define an access location appropriate for the RWP.
   - Review the inventory at the applicable Access Control Points and shall verify that Personal Protection Equipment (PPE), instruments and other safety-related equipment necessary to support the requirements of the RWP are available.
3. Prior to entry, all personnel working under an RWP must:
   - Satisfy medical and training requirements as established in the Access Control procedure.
   - Be adequately briefed by the Radiation Protection Group regarding:
     - Work to be performed and the associated RWP requirements.
     - Safety procedures to be followed for its completion.

7.0 PRECAUTIONS AND LIMITATIONS

- Personnel shall not deviate from the requirements, precautions, or other instructions on the RWP without authorization from the RSO or designees.
- A copy of the RWP shall be posted at the work site. The original shall remain at a central location (Safety and Health office). Associated support documents containing environmental conditions (soil activities, contamination surveys, etc.) shall be maintained by the RSO and are available upon request.
- An RWP is not required when responding to emergency situations where serious consequences could result if time were taken to prepare the RWP.

8.0 APPARATUS

None

9.0 RECORDS

- Hazardous Work Permit (RWP)
- Hazardous Work Permit Access Register

10.0 PROCEDURE

10.1 Active RWP Use

1. The RP group will activate the RWP upon review and signature by the RSO.
2. A copy of active RWPs will be maintained at applicable Access Control Points.
3. The RSO or designee shall review the inventory and shall verify that PPE, instruments and other safety-related equipment necessary to support the requirements of the RWP are available at the applicable Access Control Points. Inventory reviews shall also be performed, as necessary, during the course of work on the RWP.
4. All workers who will be working on tasks supported by an RWP will be provided an initial briefing on the RWP by a Safety and Health representative:

- Upon their entry on the RWP.
- Upon initial entry following revision of a RWP.
- When significant changes occur in the work area.

5. The purpose of the briefing is to ensure:
   - All Safety and Health conditions, requirements, special precautions, are fully understood by the workers.
   - Ensure that all anticipated tools, materials, and equipment are assembled for the work.
   - Ensure that work party members have been issued any radiological monitoring or protective devices specified for the work.
6. All personnel will read and verify that they understand and agree to comply with the terms of the RWP by signing in on the RWP Access Register (Attachment 2).
7. While working under an RWP, personnel are responsible to know and understand:
   - The tasks that fall under the RWP.
   - Procedural controls and precautions taken to:
     - Reduce spread of contamination.
     - Reduce airborne emissions of radionuclides.
     - Reduce dose to workers and the public as low as reasonably achievable (ALARA).
     - Requirements to apply the sound radiological and safe work practices taught in indoctrination and continuing training.
8. The RSO or the attending RPT have stop work authority for all phases of work under an RWP. Stop work authority can be implemented when personnel safety is jeopardized due to:
   - A change in the radiological (or other hazard) environment occurs, requiring additional controls and / or precautions.
   - If poor work practices are employed.
   - If RWP, ALARA, or procedural controls and / or precautions are violated.
9. Personnel shall sign in / out on the RWP Access Register for each entry into and egress from an area including when exiting the area for short break periods and when transferring to work on a different RWP.
10. Upon completion of work or at the end of the shift the Work Party Supervisor shall ensure that:
    - Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.

- All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the Safety and Health (S&H) Group.

10.2 Termination of RWP

1. If the work was not or cannot be completed within the duration period of the RWP, an extension of the RWP should be requested.
2. An RWP is considered "terminated upon:
   - Signature by the RSO, or designee(s) in the appropriate section on the **original** RWP.
   - If the duration period for the RWP is been exceeded and the RWP was not extended.
3. Upon Completion of an RWP task, the Work Party Supervisor shall ensure that:
   - Access Control Point and Work Area conditions are satisfactory. This includes housekeeping, safe storage of equipment, ensuring any required contamination control measures are implemented, and accurate completion of RWP Access Registers.
   - All radiological and Industrial Hygiene monitoring and protection devices that were issued have been returned to the RP Group.
4. Upon completion of the job, the RWP copy and RWP Access register shall be returned to the RP Group for disposition.
5. Completed RWP forms (originals) and RWP Access Registers are quality records. These documents shall be maintained by the RP Group until transmitted to Project Records.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Radiation Work Permit (Typical)

Attachment 2 Radiation Work Permit Access Register (Typical)

Attachment 1 (Typical)

PESI RADIATION WORK PERMIT (RWP)

NO. __ __ - __ __ __

Revision Number __

WORK DESCRIPTION:	WORK LOCATION(S):
	Start Date /Time:
	Est. Completion Date:
	Requested by:
	Request Date:

HAZARDOUS CONDITIONS

IS A RADIOLOGICAL / ALARA REVIEW REQUIRED ? **No** ☐ Yes ☐

I.H. LIMITS:	RADIOLOGICAL LIMITS	CURRENT CONDITIONS
O_2:	**Exposure Rate:**	*IH/Rad conditions are evaluated by Safety & Health personnel, as necessary, during job coverage. The adjacent IH/Rad limits are the maximum allowed by this RWP.*
LeL:	**Alpha Contamination:**	
Org. Vapors:		
DUST:	**General Area Airborne:**	
H2S:	**Limiting Isotope / DAC Value:**	

REQUIRED PERSONAL PROTECTIVE CLOTHING & EQUIPMENT (PPE)

HEAD / EYES	FEET / LEGS	BODY
☐ Hard Hat ☐ Safety Glasses ☐ Monogoggles ☐ Face Shield	☐ Sturdy Work Shoes ☐ Disposable Shoe Covers ☐ Rubber Over Shoes / Boots ☐ Other (Specify):	☐ Cotton Coveralls ☐ Tyvek Coveralls (Regular) ☐ Tyvek Coveralls (Coated) ☐ Other (Specify)
RESPIRATORY	**HANDS**	**MISCELLANEOUS**
☐ Full Face (Negative Pressure) * ☐ Powered Air Purifying* ** Specify Cartridge or Canister Type Below* ☐ Other (specify)	☐ Cotton / Work Gloves ☐ Nitrile Surgeons Gloves ☐ Rubber Gloves ☐ Other (Specify):	☐ Tape Gloves & Boots to Coveralls ☐ Fall Protection ☐ Hearing Protection ☐ Other (Specify)

ADDITIONAL REQUIREMENTS / SPECIAL INSTRUCTIONS / MONITORING REQUIREMENTS

Additional Requirements	Special Instructions
☐ "Buddy System" in Effect ☐ S&H Tech Job Coverage (Intermittent / Continuous) ☐ Confined Space Entry Permit ☐ HotWork Permit ☐ Lockout-Tagout Permit ☐ Excavation Permit ☐ Review MSDS ☐ Emergency Response Equipment ☐ Communication Method (Radio / Voice) ☐ Portable Eyewash Station ☐ Pre-Entry Monitoring ☐ S&H Tech Notification Prior to Work (Daily / Each Entry) ☐ Personnel Frisking Required (Whole-Body / Hand & Feet) ☐ ______ ☐ ______ ☐ ______	

Dosimetry	Indiv.	Group
TLD Badge		
Extremity TLD		
Other (Specify):		

Air Monitoring	Indiv.	Group
Lapel-Breathing Zone		
Low Volume		
Dust		
PID / FID		
4 Gas		

Expiration Date/Time:

This permit will be reviewed for revision as conditions change and at 1-year from date of implementation.

APPROVALS	DATE	TERMINATION	DATE
RSO		**RSO or SSHO**	
SSHO		**Reason:**	

Attachment 2 (Typical)

PESI RWP ACCESS REGISTER

RWP # __ __ - __ __ __

WORK LOCATION: ______________________________ DATE: ___ ___ / ___ ___ / ___ ___ Sheet: ___ of ___

ENTRANT BADGE NUMBER (1)	ENTRANT SIGNATURE (2)	TIME IN (3)	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TIME IN	TIME OUT	TOTAL HOURS *(RP USE)*

Notes:

(1) If no badge number assigned, print name (Last, FI, MI)

(2) Entrant signature acknowledges understanding of and agreement to comply with RWP requirements, including required personnel monitoring. Entrants are to immediately report any frisker alarms or indications of personnel contamination to RP Personnel. **Escorts shall initial after entrant signature for visitors.**

(3) Use Military Time (24 Hour) for ALL entry/exit times (ex. 7:15 AM = 0715 or 3:25 PM =1525). Log each entry/exit, including break periods.

REGISTER REVIEW / DATA ENTRY: ________________________________

TITLE:	**Radiological Surveys**	**NO.:**	RP-104
		PAGE:	1 of 6
		DATE:	May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure establishes consistent methodology for performing radiation and contamination surveys at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure is applicable to all personnel trained and qualified to perform radiation and contamination surveys at PESI.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)
3. RP-101, "Access Control."
4. RP-105, "Unrestricted Release of Requirements."
5. RP-106, "Survey Documentation and Review

4.0 GENERAL

4.1 Discussion

Radiological surveys are performed to detect and assess radiological conditions, which may be encountered at PESI.

4.2 Definitions

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

CPM: Counts per minute

Dose Rate: The quantity of absorbed dose delivered per unit of time.

DPM: Disintegrations per minute

General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

LAW: Large area Wipe (i.e., Masslinn)

MDA: Minimum Detectable Activity

Survey: An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of ionizing radiation under a specific set of conditions.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementation of this procedure.
- Ensuring appropriate radiation surveys are performed to measure and document radiation levels.
- Ensuring all completed surveys are adequately reviewed.
- Providing technical direction to the RPTs.

5.2 Radiation Protection Technician (RPT)

- Conducting and documenting radiation surveys.
- Performing all necessary pre / post use operability checks.
- Creating neat, legible, and concise records.

6.0 PREREQUISITES

- Prior to performing a radiation survey, personnel should review previous survey data and familiarize themselves with possible radiological hazards.

7.0 PRECAUTIONS AND LIMITATIONS

- Personal Protective Equipment (PPE) should be appropriate for the level of contamination expected and shall be in compliance with Site Safety & Health Plan (SSHP), Radiation Work Permits (RWPs), or other work specific controlling documents. At a minimum, gloves or tweezers should be used when handling swipes.
- Direct probe surveys may be used to demonstrate compliance with removable limits given in Attachment 1 (Acceptable Surface Contamination Levels), and discussed in RPP-105, "Unrestricted Release of Requirements." When instrumentation is used in this manner it should be capable of achieving the removable minimum detectable count (MDC) requirements.
- Surface contamination limits are contained in Attachment 1.
- Instruments used in surveys should be capable of achieving a Minimum Detectable Activity (MDA) that is less than the applicable release limits.
- In high background areas it may not be possible to achieve the required survey MDAs for beta / gamma instruments.

8.0 APPARATUS

- Radiation and contamination survey instruments

- Smears
- Masslinn
- Personal Protection Equipment

9.0 RECORDS

Survey documentation to be completed per RPP-106, "Survey Documentation and Review."

10.0 PROCEDURE

10.1 General Instructions

1. Select the survey instrument based on the anticipated hazards and dose rates as determined by a review of previous survey data and ongoing work activities.
2. Perform pre-operational and response checks in accordance with the operating procedures for the instrument.
3. Remove any defective instrument from service.
4. Obtain survey forms and any other material required to document survey results.
5. Contamination Surveys are normally done for alpha emitting constituents. In certain circumstances the RSO can dictate that a survey be performed for both alpha and beta emitting constituents.

10.2 Routine Survey Frequencies

1. The RSO shall specify areas for routine monitoring surveys and the frequency of such surveys. The RSO should maintain a routine survey frequency schedule. The schedule is NOT considered a record, and does not need to be retained.
2. The following areas should be considered for a routine survey on a DAILY basis:
   - Access Control Points.
   - Designated eating, drinking, and smoking areas within Restricted Areas.
   - Radiological Counting Labs and sample prep areas.
   - Any other area specified by the RSO.
3. The following areas should be considered for a routine survey on a WEEKLY basis:
   - High Traffic areas on the PESI Site.
   - Operating high-efficiency particulate air (HEPA) exhaust areas.
   - Highly occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., the boot change area, equipment floorboards, and workshops).
4. The following areas and equipment should be considered for a routine survey on a MONTHLY basis:
   - Occupied offices.
   - Storage areas.

- Occupied areas within the radioactive Materials Area that could be a source of personnel contamination or an intake of radioactive materials (e.g., equipment storage areas).

5. The following should be done on an as-needed basis:

   - Incoming Surveys

     The RSO can direct that incoming surveys be performed on equipment and materials arriving onto the site. The purpose of an incoming survey is to protect the client from financial liability associated with decontaminating equipment that arrived on the site with existing contamination. The degree of thoroughness of the survey and the requisite cleanliness of the equipment is at the discretion of the RSO.

   - Surveys of Materials Vehicles, and Personnel leaving Restricted Areas

     All materials, vehicles, and personnel shall perform surveys upon leaving Restricted Areas that have a potential for spread of contamination. The RSO or designee can direct that additional surveys be performed as needed to monitor for spread of contamination.

- Direct Total Contamination Surveys
  1. All items being surveyed should appear to be clean prior to being surveyed. To the extent possible, all interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
  2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
  3. Determine and record the background count in the area to be surveyed. Ensure that the background is representative of the measurement to be taken. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
  4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
  5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance. The count time should be consistent with the MDA calculation. A typical count times is one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.

6. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
   - **Beta-Gamma Probe** - In high background areas it may not be possible to achieve the required survey MDAs. This should be noted on the survey cover sheet, and should be brought to the attention of the RSO.
   - **Alpha Probe** - The performance check background may be used in place of background count in the area to be surveyed. A good practice is to check the probe for light leaks or for faulty cables if positive results begin appearing.
7. All measurements shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm^2," and "dpm/probe."
8. Direct non-smearable hot spots may be averaged over 1 square meter to determine compliance with release levels. If the entire item is less than 1 square meter in area, the entire surface area may be averaged. Bolt on parts of a vehicle should not be considered separate items.
   - The method for determining an average activity is to mark a 1 square meter area on the piece to be surveyed that is roughly centered on the hot spot. Take 1 measurement at the highest activity point of the hot spot. Take 4 (or more) other measurements within the square meter at locations representative of the whole square meter. Record count-rate of each individual measurement. Calculate the activity of all measurements being averaged, including those that are less than the MDA and those with a calculated activity less than zero. Calculate the average of all measurements and record on the survey form.
9. Complete the appropriate survey form.

10.3 Removable Contamination

With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.

1. All items being surveyed shall be clean prior to being surveyed. All interior and exterior surfaces should be free from oil and visible dirt. The RSO may dictate the required degree of cleanliness, based on the purpose of the survey and the history of the item being surveyed.
2. Wipe each location of interest with moderate pressure area using a standard 1 ¾-inch swipe. The area wiped should be approximately 100 cm^2. Larger areas may be wiped. It can be inferred that if the wipe meets the required limit for 100 cm^2 when it was actually taken from a larger area, the object will pass the 100 cm^2 criteria. No special documentation is required if the wiped area exceeds 100 cm^2. If the object is smaller than 100 cm^2, the area of the entire object should be wiped.
3. Large area wipes (LAW), also commonly referred to by the trade name "Masslinn" may be used to <u>supplement</u> smear surveys for removable

contamination. The use of LAWs should be documented on the survey form with the notation "LAW," or equivalent.

4. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
5. Record the location of each wipe on the appropriate survey form. It is preferable to record the location by circling the sequential number location on a survey map where the wipe was taken.

10.4 Analyzing Swipes

1. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
2. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
3. Determine and record the background count-rate. Calculate and record the MDA on the appropriate survey form. Verify the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. In no case shall the background count time be less than the sample count time.
4. Remove each swipe from the paper backing, as needed. The use of tweezers is recommended.
5. Place the swipe in the counter and close.
6. Count for the designated counting time.
7. Record the gross result under cpm in the appropriate column (either alpha or beta-gamma) of the survey form.
8. Calculate and record the activity. Removable contamination survey results shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm^2" and "dpm/LAW."

10.5 Gamma Surveys

1. Routine gamma surveys may be used to detect the gradual buildup of gamma emitting contaminated materials in soils. This may occur at heavy equipment, heavy traffic, or egress points from contaminated areas. Normal uncontaminated trash should be gamma surveyed prior to leaving the site.
2. Obtain proper instrumentation for the survey. Ensure that the instruments are currently calibrated and have been performance checked prior to the survey.
3. Perform the survey with the appropriate detector using techniques specified by the RSO.
4. Complete the appropriate survey form.

10.6 Gamma Dose Rate Surveys

- Obtain proper instrumentation. Ensure that the instrument is currently calibrated and has been performance checked prior to the survey.

- When entering areas with known radiation levels, select the appropriate scale.
  - Observe the meters as you enter the area. If necessary, change scales to maintain on-scale reading.
- Perform gamma dose rate surveys as follows:
  - Monitor dose rates from the lower thighs to head level, recording the highest level as General Area Dose Rate.
  - Monitor dose rates 30 cm (12 inches) from a significant radiation source recording the highest level as General Area Dose Rate.
  - Additional measurements are necessary to determine Transport Index for shipping per procedure PP-8-810, "Conveyance Survey."
  - If dose rate sources are predominantly from overhead, then denote on survey.
  - Perform contact gamma dose rate measurements with the detector within ½-inch of the surface to be surveyed.
  - Additional measurement locations should be clearly identified in survey documentation.
  - Record all survey results on the appropriate survey form.

11.0 CALCULATIONS

11.1 Sample Activity

$$DPM = \frac{\left(\frac{TotalSampleCounts}{SampleCountTime}\right) - \left(\frac{TotalBkgCounts}{BkgCountTime}\right)}{(E)\ (A)}$$

where:

E = Instrument Efficiency
A = Area correction factor, if applicable

11.2 Minimum Detectable Activity (MDA)

The following MDA equation is to be used for a background count time equal to the sample count time:

$$MDA = \left(\frac{(3 + 4.65\sqrt{B}\ )}{(E)(A)(T_S)}\right)$$

where:

Ts = Sample count time
E = Instrument efficiency

A = Area correction factor, if applicable

B = Background cpm

The following equation is to be used for a background count time equal to 5 or more times the sample count time:

$$MDA = \left(\frac{(3 + 3.29\sqrt{B})}{(E)(A)(T_S)} \right)$$

12.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

13.0 ATTACHMENT

Attachment 1 Acceptable Surface Contamination Levels

Attachment 1

Acceptable Surface Contamination Levels

NUCLIDE[a]	AVERAGE[b c] dpm/100 cm^2	MAXIMUM[b d] dpm/100 cm^2	REMOVABLE[b e] dpm/100 cm^2
U-nat, U-235, U-238 and associated decay products	5,000	15,000	1,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	15,000	1,000

Notes:

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.

[d] The maximum contaminated level applies to an area of not more than 100 cm^2.

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

*Source:USCG / USEPA EM 385-1-80 Table 6-4 Acceptable Surface Contamination Levels, 1985.

Note: The acceptable surface contamination levels for Th-nat will be used unless subsequent sampling indicate the presence Ra-226, Ra-228, Th-230, Pa-231, or Ac-227 in concentrations greater than that of the parent nuclide. The RSO will determine if contamination limits should be modified for a specific activity or location based on available data.

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE:	**Unrestricted Release Requirements**	**NO.:**	RP-105
		PAGE:	1 of 5
		DATE:	May 2014

APPROVED:

_____________________________ 5/31/14
Technical Services Manager Date

_____________________________ 5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This project procedure describes the method of surveying equipment, materials, or vehicles for release for unrestricted use at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This project procedure applies to all site personnel responsible for the unrestricted release of equipment and materials used in a Restricted Area. This procedure is not used for vehicles that are transporting radioactive materials. Vehicles conveying radioactive materials also must follow USDOT Regulation 49 CFR Part 173.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)
3. NRC Regulatory Guide 1.86.
4. RP-104, "Radiological Surveys"

4.0 DEFINITIONS

CPM: Counts per minute

DPM: Disintegrations per minute

Equipment and Material: Equipment and material refers to any item used in a Restricted Area to support work activities (i.e., hand tools, heavy equipment, plastic, etc.).

LAW: Large Area Wipe (i.e., Masslinn)

Unrestricted Release: Release of equipment and / or material to the general public.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Ensuring adequate staffing, facilities, and equipment are available to perform the survey tasks assigned to Radiation Protection personnel.
- Approving purchase or acquisition of equipment necessary to perform surveys.
- Ensuring that surveys take place in appropriately posted areas.
- Reviewing results of survey data as required to determine acceptability for release of items.
- Dispositioning materials that cannot be released based on survey results.
- Investigating and initiating corrective actions for the improper release of radiologically contaminated material.

5.2 Radiation Protection Technician (RPT)

- Identify equipment and material to be surveyed for unrestricted release.
- Performing and documenting contamination surveys.
- Posting, securing and controlling radioactive material that cannot be released.
- Releasing material in accordance with this and implementing procedures.

5.3 Project Personnel

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.

6.0 EQUIPMENT AND MATERIAL

- Alpha Detector
- Beta-Gamma Detector
- Portable Ratemeter / Scaler
- Scintillation or Gas-Flow Proportional Lab Alpha / Beta Counter
- Survey forms
- Cloth smears
- Masslinn™ type cloths

7.0 INSTRUCTIONS

7.1 General Instructions

Prior to conducting any surveys, ensure that all survey instrumentation has been response checked, is in operating within control limits and has not been removed from service.

- Response checks shall be performed daily.
- Background measurements are to be taken prior to use at the point of use. The background count time shall be greater than or equal to the sample count time.

- Verify that the MDA has been calculated for the background at the point of use and is less than the applicable site release criteria. Refer to RPP-104, “Radiological Surveys,” for the MDA calculation.
- Survey results are converted from counts per minute (cpm) to disintegrations per minute (dpm). A sample “cpm to dpm” calculation is attached for review and use at the end of this procedure.

7.2 Release of Items for Unrestricted Use

1. Surveys for both total and removable contamination shall be made in accordance with Section 7.3 (below) on all equipment, materials or vehicles which have either been in a Restricted Area or which may be potentially contaminated.
2. With RSO approval, removable contamination surveys may be disregarded, provided that direct survey measurements and instrument MDAs are below site removable contamination limits for release.
3. RP personnel will determine which items located outside a Restricted Area may be potentially contaminated based on their use, site history, or previous survey data. The potential for these objects to have become contaminated by airborne radioactive materials must be considered. This could include items that are used to support site activities, such as office equipment, cleaning devices, furniture, trailers, etc., even though direct contact may not have occurred.
4. Items which have a potential for internal contamination of inaccessible surfaces shall be evaluated by the RSO or designee prior to release.
5. All items to be released shall be surveyed in such a manner as to fully demonstrate that accessible surfaces comply with the surface contamination release criteria specified in RP-104, “Radiological Surveys.”
6. Items that do not meet release criteria shall be decontaminated until release criteria is met or shall be disposed of as radiological waste.
7. Air intakes / filters on motorized equipment should be surveyed as an indicator of potential internal contamination. Notify the RSO or designee if air intake / filter surfaces indicate the presence of contamination. Contaminated air filters shall be removed and disposed of as radiological waste.
8. To the extent practicable, visible dirt and mud or other material shall be removed from surfaces prior to survey.
9. The RSO or designee, shall review all survey data prior to the release from the Controlled Area.

7.3 Direct Surveys Scans and Static Measurements

1. Surfaces shall be dry and cleaned, to the extent practicable prior to performing direct alpha measurements.
2. The RSO may authorize the short-term relocation or staging of equipment / vehicles for direct measurements in any portion of the Controlled Area. This is provided that the item has been verified to be clean of removable

contamination prior to removal from a Restricted Area and fixed contamination producing general area dose rates greater than 0.2 mrem/hr is not anticipated.

3. Alpha detectors should be placed within ¼-inch of the surface to be surveyed. Beta detectors should be placed within ½-inch of the surface to be surveyed. Use caution to not contaminate or damage the detector surface.
4. Perform a scanning survey of the item. Concentrate survey measurements on areas most likely to be contaminated. The fraction of the total area scanned is subjective, based on technician experience, an item's use history, and RSO guidance. Typically, the scan frequency is a minimum of 10% of accessible surface areas.
5. Obtain static measurements at locations with the highest potential for contamination. The number of survey points selected is subjective, based on technician experience, an item's use history, and RSO guidance.
6. Static measurement count times shall be appropriate for desired MDAs. Typical count times are one minute for digital scalers and until the meter reading stabilizes for analog ratemeters.
7. Record and identify all locations surveyed on the appropriate survey form(s). The use of diagrams or sketches is recommended.
8. All measurements shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100 cm^2" and "dpm/probe."

7.4 Removable Contamination Surveys

1. "Cloth" smears shall be used for smear surveys.
2. A notation (e.g., smear number, date, time, location, etc.) should be made on the smear envelopes to ensure proper smear tracking. Smears may also be numbered using a pen or marker prior to use.
3. Using moderate pressure, swipe an area of 100 cm^2 (4-inch square area or equivalent) of the surface at the selected location. Smear surveys should be performed at the same location that direct surveys were performed.
4. Large Area Wipes (LAW), also commonly referred to by the trade name "Masslinn," may be used to <u>supplement</u> smear surveys for removable contamination. The use of LAWs should be documented on the survey form with the notation "LAW" or equivalent.
5. Ensure each used swipe (i.e., smear or large area wipe) is handled, stored, and transferred in such a fashion as to prevent to loss of sampled material or cross-contamination with other personnel and other swipe samples.
6. Smear samples should be counted using available scintillation or gas-flow proportional laboratory counters, when practicable. Field instruments may be used for smear counting at the discretion of the RSO.
7. LAW samples may be counted using field instruments. The use of laboratory counters is inappropriate.
8. Removable contamination survey results shall be reported in units of "dpm" unless otherwise directed by the RSO. Examples include "dpm/100cm^2" and "dpm/LAW."

9. Ensure all results are documented on the appropriate survey form. Lab printouts may be attached and referenced on the survey form.

8.0 CALCULATIONS

MDA and Sample Activity formulas are located in RPP-104, “Radiological Surveys.”

9.0 DOCUMENTATION

- Survey forms shall be completed in entirety. This includes attaching printouts, diagrams, or other supporting documentation, appending sequential page and survey tracking numbers, a review for completeness and accuracy, and appending the appropriate signatures of personnel performing the survey and / or analyzing samples.
- Once complete, the survey package shall be submitted to the RSO or designee, for final review and approval signature.
- Survey documentation shall be maintained according to established RP document control and retention requirements.

10.0 ATTACHMENT

None

PERMA-FIX ENVIRONMENTAL SERVICES		
TITLE: **Survey Documentation and Review**	**NO.:**	RP-106
	PAGE:	1 of 6
	DATE:	May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure establishes consistent methodology for documenting radiological surveys and provides criteria for the review of these surveys.

2.0 APPLICABILITY

This procedure is applicable to all radiological surveys excluding air samples.

3.0 REFERENCES

1. 10 CFR 20, "Standards for Protection Against Radiation."
2. PESI "Radiation Protection Plan (RPP)
3. RP-104, "Radiological Surveys."

4.0 GENERAL

4.1 Discussion

The results of surveys will be documented on survey forms or in designated logs as approved by the Radiation Safety Officer (RSO). Survey data will contain enough detail to provide personnel with adequate information concerning radiological conditions existing in the area surveyed.

The RSO or designee will review completed survey documentation to ensure appropriate, adequate and complete information is recorded. The individual reviewing the survey will ensure that the recorded results are legible, in accordance with Radiological Protection Program (RPP) implementing procedures, consistent with anticipated levels, and will determine the reason for any variances.

4.2 Definitions

Airborne Radioactivity Area (ARA): Means any area where the measured concentrations of airborne radioactivity above natural background exceed, or are likely to exceed, 25% of the Derived Air Concentration (DAC) values listed in 10 CFR 20, Appendix B, Table I, Column 3.

Contamination Area (CA): Means any area accessible to personnel with loose surface contamination values in excess of the values specified in RP-104 , "Radiological Surveys, or any additional area specified by the Radiation Safety Officer (RSO). The Contamination Area posting requirement is more restrictive than the Radioactive Material Area posting requirement. Any area posted as a Contamination Area shall also be considered to be a Radioactive Materials Area.

Contact Dose Rate: A radiation dose rate as measured at contact or within 1/2 inch of the surface being measured.

General Area Dose Rate (GA Dose Rate): The highest radiation dose rate accessible to any portion of the whole body measured at a distance of 30 cm (12 inches) from a significant radiation source or combination of sources.

Radiation Work Permit (RWP): Means a document or series of documents prepared by Radiation Protection to inform workers of the radiological and industrial hygiene conditions, which exist in the work area and the radiological requirements for the job.

Radiation Area (RA): Means any area, accessible to personnel, where the whole body dose rate can exceed 5 mrem in 1 hour at 30 cm from the source.

Radioactive Material: Material activated or contaminated by the operation or remediation activities and by-product material procured and used to support the operations.

Radioactive Materials Area (RMA): Any area or room where quantities of radioactive materials in excess of 10 times the 10 CFR 20, Appendix C quantities are used or stored, or any area designated by the RSO which does not exceed the site Contamination Area criteria.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The Radiation Safety Officer (RSO) or designee is responsible for reviewing radiological surveys performed by Radiation Protection Technicians (RPT).

5.2 Radiation Protection Technician (RPT)

- RPTs are responsible for documenting surveys in a legible manner on approved forms.

6.0 PREREQUISITES

- Surveys for radiation and contamination have been performed in accordance with RP-104 "Radiological Surveys".

7.0 PRECAUTIONS AND LIMITATIONS

- Surveys for airborne radioactivity will be documented in accordance with RP-107, "Measurement of Airborne Radioactivity."

8.0 APPARATUS

Survey Forms

9.0 RECORDS

- PESI Survey Form (Attachment 1)
- PESI Survey Log Number Form (Attachment 2)
- Radiation Protection Technician (RPT) Logbooks

10.0 PROCEDURE

The methods outlined in this procedure are intended to assure the clear and concise transfer of survey information. Variations or deviations from the protocols in this procedure are permitted if the clear transfer of information is maintained.

10.1 Documentation

10.1.1 General

1. Record all information on survey forms in a neat and legible manner.
2. Document all surveys on a form with approved project heading. Technician logbooks may be used for documenting surveys (e.g., daily routines, material transfers, minor posting changes, etc.) as authorized by the RSO and providing instrument serial numbers are documented with survey data.
3. When recording information on survey forms, check all appropriate boxes and circle all appropriate answers.
4. Use a survey form with pre-drawn diagrams when available. If not, draw a diagram or picture of the object surveyed. Should a diagram not be appropriate, use a lined survey form.
5. Assign the next sequential survey number to the survey from the survey number logbook.
6. Complete the following information for all surveys:
   - Date and time of survey
   - Location of survey
   - Instrument type and serial numbers and associated supporting information (i.e., detector efficiencies, calibration dates, background values, etc.)
   - HWP number, if applicable
   - Reason for survey

- Name and signature of surveyor

7. Indicate Radiological Hazard Area boundaries on the survey form using x's and -'s (-x-x or **).

8. Note the posted Radiological Hazard using common designator such as

    - Contamination Area = CA
    - Radiation Area = RA
    - Radioactive Material Area = RMA
    - Airborne Radioactivity = ARA

9. The use of Greek alphabet and other nuclear industry standard nomenclature (e.g., “k” = 1000) is acceptable when documenting surveys.

10.1.2 Survey Log Number Book:

1. Survey log number book is to be used to assign a unique sequential number to each survey form package. This number provides the ability to track individual surveys as well as ensuring the submittal of a complete documentation package for archiving.

2. Unless otherwise directed by the RSO, survey numbers will be assigned with the following format:

    NFSSyyRS.xxxx

    “NFSS” corresponds to “Niagara Falls Storage Site, ” yy is the last two digits in the year, “RS” refers to “Radiological Survey,” and xxxx refers to the sequential survey number.

3. As surveys are generated, the RPT will take the next sequential number on the form and fill in the remaining boxes with a brief description of the reason for the survey as well as the date and RPT’s initials.

10.1.3 Radiation Surveys

1. Indicate GA dose rates by underlining the radiation level on the Survey Form at the appropriate location (Example: <u>25</u> uR/hr).

2. Indicate CONTACT dose rates by recording the radiation level with an asterisk on the Survey Form at the appropriate location (Example: * 25 ur/hr). If there are corresponding 30 cm and GA readings, document them as follows:

    * CONTACT / @ 30 cm / GA

3. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.

10.1.4 Contamination Surveys

1. Indicate survey locations by placing sequential numbers within a circle on the Survey Sheet. The Survey Sheet has corresponding direct and transferable columns for both alpha and beta / gamma activity.

2. Use a legend to inform the reviewer of any other notation utilized or if deviating from standard protocol.

3. The use of the letter “k” to indicate units of a thousand is acceptable.

10.2 Technician Review and Evaluation

10.2.1 After completing the surveys, evaluate the results against previous surveys or anticipated results.

10.2.2 Verify that radiological boundaries and postings are correct in accordance with RPP-102, "Radiological Posting Requirements."

10.2.3 Take any immediate actions required based on survey results.

10.2.4 Ensure all relevant supporting documentation (e.g., count room print-outs, etc.) are attached to the survey package and that the package is properly paginated.

10.2.5 Submit documentation to the RSO or designee for supervisory review.

10.3 Supervisory Review

10.3.1 Ensure that the survey form is complete and legible.

10.3.2 Ensure that all required information has been completed.

10.3.3 Ensure that any changes, single line cross-outs, or deletions are initialed and dated at time performed.

10.3.4 Verify that results are consistent with those anticipated.

10.3.5 If results are not consistent, ensure that appropriate actions have been taken to explain the results or re-examine the area.

10.3.6 Sign-off in the appropriate review section of the survey form and submit package to RP Document Control for retention / transmittal to Project Files.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 PESI Survey Form (Typical)

Attachment 2 PESI Survey Log Number Form (Typical)

Attachment 1 (Typical)

FUSRAP Survey Data Sheet

Survey No.:		**Item Surveyed:**		**Project:**
Date:		**Contaminant/Limits:**		
Survey Tech.:		**Comments:**		
Count Rm. Tech.:				
Date Counted:				
Survey Type:				
Level of Posting:				

Parameters	*Rate*	*Gamma*	*Corr uR*	*Total*		*Removable*	
				Alpha	Beta-Gamma	Alpha	Beta-Gamma
Instrument Model:							
Instrument SN:							
Cal. Due Date:							
x, y int.: *Efficiency:*	N/A						
BKG: *Bcpm**:*			N/A				
ACF:							
tB:							
tS:							
Lc:							
MDC:							

Notes:

ACF = Area Correction Factor
T_b = Background Count Time
T_s = Sample Count Time
R_b = Bkgd count rate
**Bcpm = Background cpm = R_b

Direct
(dpm) = (cpm - Bcpm)/(eff * ACF)

Removable
(dpm) = (cpm - Bcpm)/ eff
* dpm readings are per 100cm^2

No.	*Descriptions*	*x*	*y*	*z*	*uR/hr*	*cptm*	*uR/hr*	*cpm*	**dpm*	*cpm*	**dpm*	*cpm*	**dpm*	*cpm*	**dpm*

Attachment 2 (Typical)

FMSS SURVEY TRACKING LOG (2002)

Survey No.	Survey Date	Item/Area Surveyed	Project #

APPROVED:

______________________________ 5/31/14
Technical Services Manager Date

______________________________ 5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure establishes the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples. Radiological air sampling and analysis is performed to monitor concentrations of radionuclides in the air for purposes of tracking internal radiation exposure to occupational radiation workers, determining appropriate respiratory protection devices, establishing radiological posting boundaries, verifying effluent airborne radioactivity concentrations, and providing information on radiological conditions in the work area.

2.0 APPLICABILITY

This procedure applies to all radiological air monitoring activities performed in support of Perma-Fix Environmental Services (PESI) activities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. Perma-Fix Environmental Services (PESI), "Radiation Protection Plan (RPP)
3. Rock, R.L., *Sampling Mine Atmospheres for Potential Alpha Energy Due to the Presence of Radon-220 (Thoron) Daughters*, Informational Report No. 1015, United States Department of the Interior, Mining Enforcement and Safety Administration, 1975.
4. Kusnetz, H.L., Radon Daughters in Mine Atmospheres, A Field Method for Determining Concentrations, Am. Ind. Hyg. Assoc. Quat., Vol. 17, No. 87, 1956.
5. ANSI N13.1, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.
6. Regulatory Guide 8.25, Air Sampling in the Workplace.
7. 29 CFR 1910.1096, United States Occupational Health & Safety, Ionizing Radiation.

4.0 DEFINITIONS

Airborne Radioactivity: Radioactive material in any chemical or physical for that is dissolved, misted, suspended, or otherwise entrained in air.

Ambient Air: Air in the volume of interest, such as room atmosphere, as distinct from a specific stream or volume of air that may have different properties.

Annual Limit on Intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent (CEDE) of 5 rems or a committed dose equivalent (CDE) of 50 rems to any organ or tissue.

Breathing Zone (BZ): A uniform description of the volume of air around the worker's upper body and head which may be drawn into the lungs during the course of breathing.

Committed Dose Equivalent (CDE): The dose equivalent to tissues or organs of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE): The sum of committed dose equivalents (CDEs) to various tissues in the body, each multiplied by the appropriate weighting factors found in 10 CFR 20.

Derived Air Concentration (DAC): The concentration of a given radioactive nuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work (1.2 m^3 of air per hour), would result in an intake of one (1) ALI.

DAC-hour (DAC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours. A facility may take 2000 DAC-hr to represent 1 ALI.

Grab Sample: A single sample of ambient air collected over a short time.

Maximum Permissible Concentration (MPC): That concentration of radionuclides in air or water that will result in the Maximum Permissible Body Burden or Organ Burden and result in a whole body or organ receiving the annual dose limit if breathed in by a worker for 2000 hours.

Monitoring: The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

MPC-hour (MPC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the MPC for each radionuclide) and the time of exposure to that radionuclide in hours.

Occupational Dose: An individual's ionizing radiation dose (external and internal) received as a result of that individual's work assignment.

Protection Factor: The degree of protection given by a respirator. The protection factor is used to estimate radioactive material concentrations inhaled by the wearer and is expressed as the ratio of ambient concentration of airborne radioactive materials to the concentration that can be maintained inside the respirator during use.

Representative: Sampling in such a manner that the sample closely approximates both the amount of activity and the physical and chemical properties of the material (e.g., particle size and solubility in the case of aerosol to which workers are exposed). Air sampling performed within the Breathing Zone (BZ) is considered representative of the airborne radioactive material concentration inhaled by the worker.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Manages the implementation of this procedure.
- Ensures technicians performing activities under this procedure are competent and have sufficient experience to perform assigned tasks.

5.2 Radiation Protection Technician (RPT)

- Initiates, collects, submits, counts, and documents air samples according to the requirements of this procedure, and the SSHP.
- Ensures he / she has sufficient experience and / or knowledge to perform assigned duties under this procedure.

6.0 PRECAUTIONS AND LIMITATIONS

- Running air samplers for extended periods may cause excessive dust loading of the filter media. The frequency of filter change-out should be increased if excessive dust loading is observed.
- Air samplers shall not be used in combustible / explosive atmospheres.
- Air sampling and sample counting equipment shall not be operated beyond their respective calibration periods.
- Air samples shall be taken in such a manner as to not contaminate the filter with materials that were not airborne during the sample interval or by re-suspension of loose contamination from surfaces near the sampling head.
- Sampler exhaust may cause the re-suspension of loose surface contamination if the sampler is positioned improperly.
- Consider higher volume air samplers when covering short duration tasks.
- The decision to provide individual monitoring devices to workers is influenced by the expected levels of intake, likely variations in dose among workers, and the complexity of measurement and interpretation of results.

7.0 ACTION STEPS

7.1 Air Monitoring Methods

1. Utilize the following monitoring methods to implement the radiological air monitoring program:
   - General Area (GA) Air Monitoring
   - Breathing Zone (BZ) Air Monitoring
   - Passive Radon Monitoring
   - Particulate Radon Grab Samples
   - Perimeter Monitoring, frequently referred to as Air Environmental (AE)
2. Air sampling equipment should be placed so as to:
   - Not directly contact a contaminated (transferable) surface.
   - Minimize interference with the performance of work.
   - Be easily accessible for changing filters and servicing.
   - Be downstream of potential release points.
   - Minimize the influence of supply airflow.
3. An airflow study of any indoor area to be monitored should be performed prior to placement of the sampler (other than BZ samplers). Additional studies should be performed after changes in the work area setup, ventilation systems, or seasons, if seasonal changes may affect airflow patterns.
4. Perform BZ air sampling in occupied areas where, under typical conditions, a worker is likely to be exposed to an air concentration of 10 % or more of the DAC.

7.2 General Area (GA) Air Sampling

1. GA samples are typically taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. GA sampling shall be performed with instrumentation operating at volumes capable of meeting the Minimum Detectable Concentration (MDC) values established in the Technical Basis Document for Dosimetry and Air Sampling.
3. GA samples should be collected:
   - During work activities as a supplement to Breathing Zone (BZ) sampling as deemed appropriate.
   - At site boundaries to confirm effluent air discharge concentrations. These are the Air Environmental (AE) type samples.
   - At discharge points to determine the worst case airborne radiological conditions.
4. Document airflow studies, if performed in the appropriate project logbook or as directed by the RSO.

5. Select a calibrated low / high volume sampler with the appropriate glass fiber air filter and place the sample head into position. The fuzzy side of the filter should face outwards.
6. Turn the sampler ON. At a minimum, document the following information on the air filter envelope or log sheet:
   - Sampling station identifier (as determined by the RSO)
   - Sampler model
   - Serial number
   - Date / time on
   - Flow rate
   - On by (individual starting sampler)
7. When air monitoring is complete, observe the sampler flow rate and turn the sampler off. At a minimum, document the following information on the air filter envelope or logsheet:
   - Date / time off
   - Flow rate
   - Off by (individual terminating sample)
8. Remove and / or replace the sample head and filter using caution to prevent cross-contamination.
9. Store the filter in a protective container to minimize the loss of collected material.
10. Submit sample to counting lab for analysis.

7.3 Breathing Zone (BZ)

1. Specific instructions on the use and calibration of Lapel Samplers are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Collect BZ samples during entries into posted airborne radioactivity areas and during activities which have a reasonable potential of producing airborne radioactivity (e.g., excavating contaminated soils, surface destructive activities on surfaces with fixed contamination) as determined by the RSO.
3. Position the sampler on the individual representative of the worst-case exposure for the group if a single lapel sampler is used for multiple members of a work group. Base this selection on operating experience and consultation with the RSO. A single lapel sampler should be used for a group of no more than four workers spending greater than one hour in the work area under the same RWP.
4. Ensure the sample head is positioned as close to the breathing zone as practical without interfering with the work or the worker.
5. Operate lapel samplers according to the appropriate instrument use procedure. At a minimum, document the following information on the air filter envelope or log sheet:
   - Wearer's name(s)
   - Applicable Hazardous Work Permit (HWP) number

- Sampler model / serial numbers
- Date / time On
- Flow rate (sampler must be running)
- On by (individual starting sampler)

6. Upon exit from the work area, note the flow rate, turn the sampler OFF and detach from the worker / object. Note that sampling may be suspended / restarted during the workday to facilitate break periods. Accurate volume tracking is crucial during these periods of non-operation.
7. Perform necessary post-operation sampler checks according to the specific instrument use procedure.
8. Carefully, remove the air filter from the sample head and place in air filter envelope. Complete the pre-printed air filter envelope or sample log sheet:
   - Date / time off
   - Flow rate
   - Off by (individual stopping sampler)
9. Submit sample to Counting Room for analysis.

7.4 Radon and Thoron Progeny

1. High volume or low volume grab samplers such as HV-1, LV-1, or RAS-1 (typically in the 35-75 lpm range) should be used for collecting radon and thoron samples.
2. Radon and thoron samples should be collected:
   - During work activities as deemed appropriate by the RSO or designee.
   - At restricted area boundaries as deemed appropriate by the RSO or designee.
   - Each frequently occupied work location should have its own samplers.
   - Airflow patterns should be considered in placing samplers so that the sampler is likely to be in the airflow downstream of the source.
   - A simultaneous background sample shall be taken upwind of all activities when radon and thoron sampling is performed. This sample is critically important.
   - When collecting a radon and thoron breathing zone sample, the sampler should be located in the breathing zone for the worker. Preferably it should be held immediately downwind of the worker and moved around with the worker.
3. Select a calibrated high volume sampler with a 47 mm filter and place the sample head into position. The preferred filter is a membrane filter such as the F&J Specialty Products, Inc. model number A020A047A or equivalent. Alternatively, a glass fiber filter such as the F&J Specialty Products, Inc. model number AE-47 or equivalent can be used

4. Turn the sampler ON and complete the required information on the air filter envelope to include:
   - RWP number, if appropriate
   - Sampler model and serial number
   - On date, time, and flow rate
   - On by (site worker initials)
   - Sample location
5. Collect a sample for exactly 5 minutes, with no more than a 5-second uncertainty. Exercise caution when handling sample head so as not to cross-contaminate the air filter.
6. Remove air filter from sample head and place in air filter envelope. Complete the required information on the air filter envelope including:
   - Off date, time, and flow rate
   - Site worker stopping the sampler
7. Submit the sample to the counting room within 30 minutes after collection. Samples must be counted between 40 and 90 minutes, or they will be void.
8. Analyze the sample in accordance with Sections 8.1 or 8.2, whichever is appropriate.
9. Alternate industry-accepted methods for Radon-Thoron monitoring may be used at the discretion of the RSO with concurrence from the Project Certified Health Physicist.

7.5 Perimeter Environmental Air (AE) Sampling

1. Perimeter samples are taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Perimeter samples are collected to verify compliance with off-site release criteria.
3. Samples are collected at locations designated by the RSO. The air sampling locations should be established at the most likely downwind perimeter boundary, as determined by evaluation of local meteorological data, and / or the nearest perimeter boundary from active work areas.
4. Perimeter samplers should be operated 24 hours a day 7 days a week if possible.
5. Filters from continuously operating perimeter air samplers are normally changed out weekly. Filter change-out of perimeter air samplers will be performed at a frequency long enough to ensure acceptable counting statistics and short enough to maintain consistent sampler flow rates.
6. Perimeter sampler operation shall be verified on a daily basis around locations when airborne generating activities are in progress. This requirement may be relaxed by the RSO for samplers with data logging capability.

7. Document daily verification (i.e., flow rate) and notify the RSO of any discrepancies. Replace filter and investigate pump operation if daily flow rates vary by greater than 20%.
8. Any sampler that is out of service due to malfunction for more than 1 hour and any invalid samples should be brought to the attention of the RSO.
9. Samples are to be collected in accordance with Section 7.2, Steps 5-10.

7.6 Passive Radon Monitoring

1. Passive radon monitoring methods include the use of either alpha track-etch detectors or electrets.
2. Detectors should be placed for a length of time, so that the minimum detectable concentration is 0.1 pCi/l or less, following manufacturer guidelines. The length of placement is generally 1 month or greater. Locations selected should be representative of the breathing zone, when practical. A simultaneous background sample should always be taken at a location unaffected by site activities. This sample is critically important.
3. Open the bag containing the detector and place the detector in a protective container to allow for air circulation. Follow manufacturer guidelines to activate the detector, as necessary.
4. Record in the logbook:
   - Sample location
   - Date and time of placement
   - Serial number of the detector
   - Initials of the worker placing the detectors
5. Ship the detector to the manufacturers processing center to read the results.

8.0 ANALYSIS OF AIR SAMPLES

General Area (GA), Breathing Zone (BZ), and Perimeter Air (PA) samples should be submitted to a counting room or off-site laboratory for gross alpha/beta analysis. Samples may be sent to an outside laboratory for isotopic analysis as necessary per the RSO.

8.1 Analysis for Radon and Thoron Progeny from a 5-Minute Low Volume Grab Sample

8.1.1 Count the sample twice for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The first count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of sample collection. The second count should start at least 5 hours after the end of the count, but not greater than 17 hours after the end of the first count. Count the sample for 5 minutes each time.

NOTE: It is not recommended that a gas flow proportional counter be used for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

8.1.2 Calculate the thoron progeny (TDC) in working levels from the delayed (second) count as follows:

$$TDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Th}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Th} = Working level factor from Graph 1 (Attachment 1).

8.1.3 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{\left(\frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF} - TDC\ x16.5\right)}{F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

TDC = Thoron Progeny determined from second count.

8.2 Alternate Method for the Analysis of Radon Progeny from a 5-Minute Low Volume Grab Sample

This section only applies to the determination of radon and not the determination of thoron.

8.2.1 Count the sample once for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of the count. Count the sample for 5 minutes.

NOTE: It is not recommended to use a gas flow proportional counter for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

8.2.2 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

9.0 REPORTS

Maintain air monitoring instrument data, sampling data, and analysis results as a quality record.

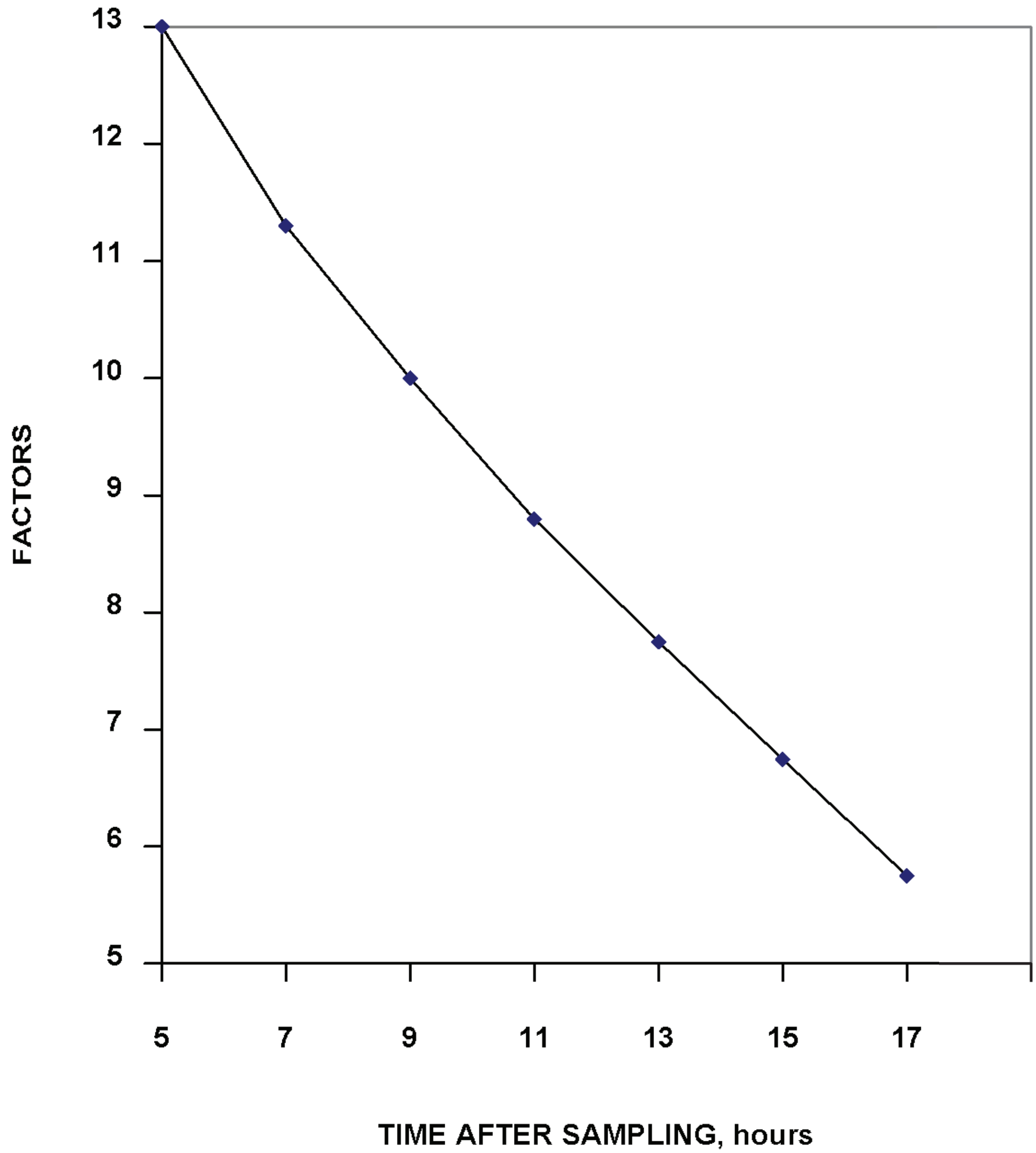
10.0 ATTACHMENTS

Attachment 1 Graph 1, Thoron Working Level Factors

Attachment 2 Graph 2, Radon Working Level Factors

ATTACHMENT 1

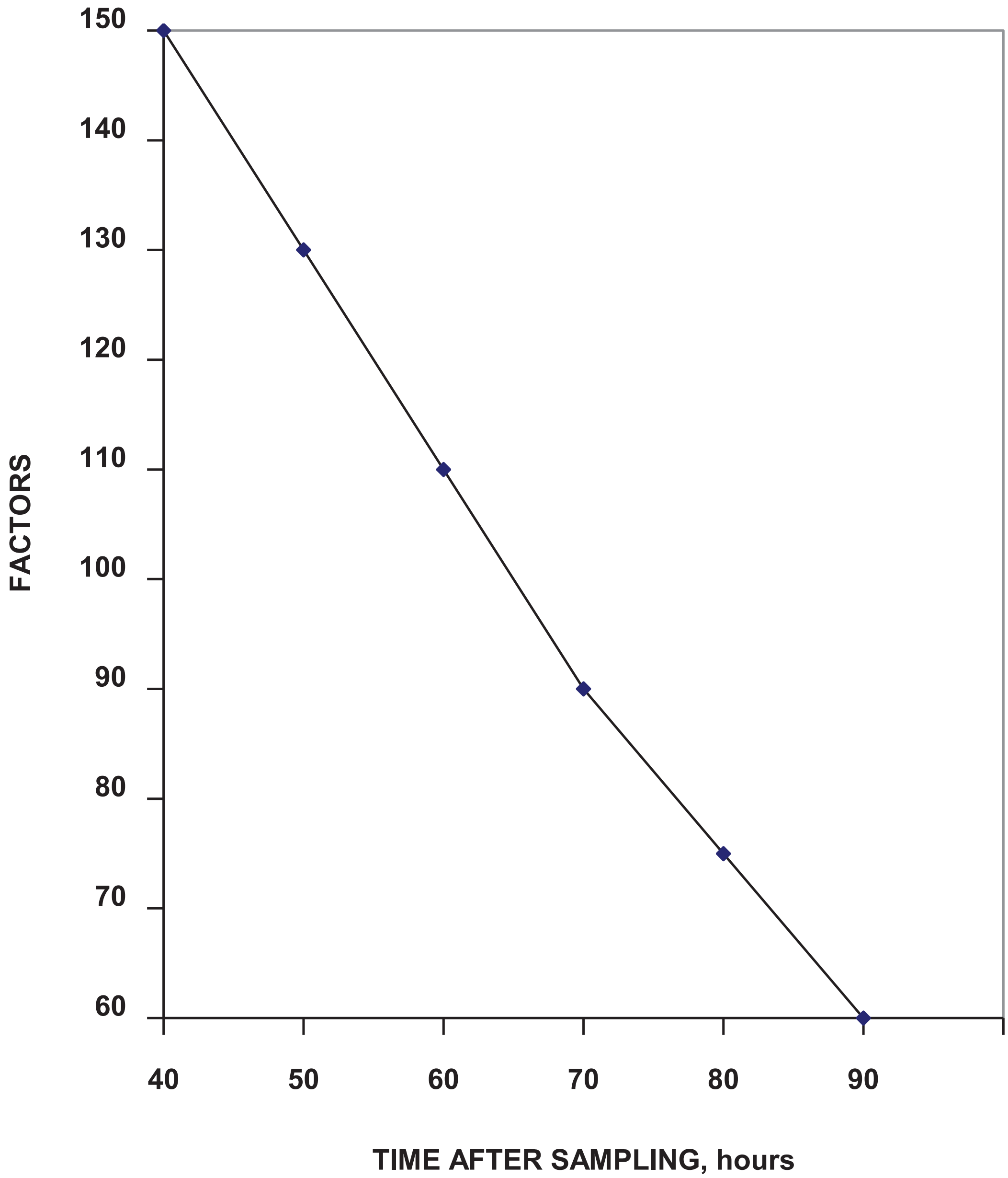
GRAPH 1, THORON WORKING LEVEL FACTORS



Time factors versus time after sampling for thoron daughter samples.

ATTACHMENT 2

GRAPH 2, RADON WORKING LEVEL FACTORS



Time factors versus time after sampling for radon daughter samples.

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Count Rate Instruments	NO.: RP-108
	PAGE: 1 of 6
	DATE: May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This procedure specifies the methods for set-up, daily pre-operational check, and operation of portable count-rate survey instruments. These instruments are used for the detection of radioactivity on personnel, on or within material surfaces, and in the environment. This procedure does not include associated instrument calibrations or cover the operation of exposure rate instruments.

2.0 APPLICABILITY

This procedure specifically addresses those meter-probe combinations that report values in units of counts or counts per minute (cpm) such as Ludlum Measurements models 2221 and 2241 Scaler-Ratemeters; and the Ludlum Model 177 Alarming Ratemeter or equivalent. These meters are mated to probes including the Ludlum Model 44-10, 44-20, and 44-62 NaI Detectors, the Ludlum Model 43-5 Alpha Scintillation Detector, and the Ludlum Model 44-9 Pancake Geiger-Mueller detectors or equivalent. Additional equivalent meters and probes may be used under this procedure without revision as approved by the RSO.

3.0 REFERENCES

1. ANSI N323A-1997, Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) Radiation Protection Plan (RPP)
4. RP-104, Radiological Surveys

4.0 DEFINITIONS

cpm: counts per minute

DFSCL: Daily Field Source Check Logsheet.

dpm: disintegrations per minute

HV: High Voltage

MDA: Minimum Detectable Activity

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control, and accountability of Radiation Protection instrumentation per the requirements of this procedure.
- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary after use.

6.0 PREREQUISITES

- Only personnel with appropriate documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.
- QA/QC requirements established by an approved survey plan (e.g., Master Final Status Survey Plan) supercede the requirements of this procedure.

8.0 APPARATUS

- Appropriate survey instruments

9.0 RECORDS

- Portable Instrument Set-Up Sheet
- Daily Field Source Check Logsheet

10.0 PROCEDURE

10.1 General

1. Ensure the meter-probe combination selected is within their acceptable calibration periods. The swapping of probes between meters is permitted, but not encouraged. The following precautions and limitations must be observed and the following action steps must be taken:
   - If the meter-probe combination is calibrated as a set, Probe swapping is not permitted, without specific RSO approval.
   - The HIGH VOLTAGE (HV) and THRESHOLD settings for the meter-probe combination shall be identical. Note that the Ludlum 177 and 2241 do not have user adjustable settings for HV and THRESHOLD.
   - An initial set-up must be performed for each meter-probe combination prior to field use.
   - A source with known pedigree must be counted to verify the efficiency is within 10% of the calibrated efficiency, as applicable.
2. The RP Group will coordinate the calibration of boxes and probes on a minimum annual basis and after major repair operations. Battery and / or cable change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational checks are required daily prior to use. Post-operational checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational check..
4. Instruments that fail operational checks or malfunction during use should be tagged or labeled “Out-of-Service” or “Do Not Use” and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
5. Instruments leaving RP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release according to the contamination criteria established in Table 1 of the Site RPP. The repair / calibration center may request a copy of the survey accompany any shipments of RP instruments.
6. Ensure meters with a “WINDOW” or “WIN” setting are set to “OUT.”
7. Instruments may be operated in the FAST response mode if necessary. This setting is recommended if the audible response cannot be heard. SLOW response shall be used when performing instrument set-up and operational checks.
8. Ludlum NaI crystals are located in the end of the probe opposite of the cable connection. Use this end for surveys.
9. Calibration stickers are attached to the instruments and detectors. Illegible stickers should be replaced prior to instrument use.
10. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and background radiation levels.

11. Source positioning devices (i.e., jigs) may be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
12. Instruments that do not have scaler capability should be set-up and checked by replacing 1-minute timed counts with static count rate measurements. Each static measurement should last until the meter reading fully stabilizes.

10.2 Instrument Set-Up

1. Inspect the meter-probe combination for physical damage or defect.
2. Complete Section A of the Portable Instrument Set-Up Sheet (Attachment 1).
3. Perform 10 1-minute source counts alternating with 10 1-minute background counts. Remove / replace the source and reposition the probe after each count. During alternating background counts, ensure that the source is sufficiently shielded so as not to impact background values.

   NOTE: Counts (Source and Background) performed with a Ludlum 43-5, or other large surface area probe, should be alternated between the Heel, Center, and Toe Positions, if the source surface is smaller than the active surface area of the probe. Instrument response can vary greatly across the probe surface.
4. Document each count on the Portable Instrument Set-Up Sheet.
5. Calculate and record the net count value by subtracting the corresponding background count from each source count.

   NOTE: Determining Sigma (Standard Deviation) values is useful when specific plans or activities require higher data quality objectives and / or when the development of control charts is necessary.
6. Calculate and record the following values from the obtained background counts:
   - Avg. Value (Sum of values / # of counts)
   - Sigma Value (Standard Deviation of all counts)
   - 20% Value (Avg. Value * 0.20)
7. Calculate and record the +/- 20% Values and the +/- 1,2, and 3 Sigma values using the AVG. VALUE as a reference point.
8. Repeat the previous two steps for determining NET COUNT acceptable ranges. The 3 Sigma value must be less than the +/- 20% value.
9. Obtain a blank Daily Field Source Check Logsheet (DFSCL) (Attachment 2) and transfer the instrument, source, and acceptable range data, as applicable, from the Portable Instrument Set-Up Sheet.
10. Place the DFSCL in the designated use location and forward the completed Portable Instrument Set-Up Sheet and submit to the RSO, or designee for review.
11. Ensure sources are stored properly after use in the designated source storage location.

10.3 Operational Check

1. Obtain the selected meter-probe combination and corresponding DFSCL (Attachment 2).
2. Record the date and time on the DFSCL.
3. Perform and document the following checks on the DFSCL, as applicable:
    - Perform a physical inspection. Observe for instrument damage. Alpha probes should be checked for light leaks by inverting the probe face towards a light source and observing instrument response. If the instrument fails to respond at all or over-responds this may be an indication of a light leak and should be investigated further, prior to proceeding.
    - Perform a battery check. Instrument Models differ in method. Some meters have a visible battery range on the meter face. The Ludlum Model 2241 has a battery indicator in the digital display that lights if the batteries require replacement. The Ludlum Model 2221 has a BAT button that brings up the battery level in the digital display. Ensure this value is at least 5.0v. Change batteries and retest as necessary.
    - Verify and adjust the HV, when possible, to match the initial set-up data. Minute differences in HV (+/- 5v) are acceptable without adjustment.
    - Perform an audio response check..
4. Perform and record a 1-minute background count. Report any abnormal background responses to the RSO, prior to instrument use. Normally acceptable background levels < 5 cpm for alpha probes, and < 300 cpm for Pancake G-M probes. Acceptable background levels for NaI probes are variable due to crystal size and based on technician experience.
5. Perform and record a 1-minute source gross count using the same source and geometry applied during initial set-up.
6. Calculate and record the net count value.
7. Compare the net count value to the acceptable range. If the instrument response is outside the acceptable range, the process may be repeated a maximum of 1 additional time before placing the instrument out-of-service.
8. If the instrument fails the pre-operational checks, mark FAIL, initial the DFSCL, and place the instrument out-of-service. Deliver completed DFSCL to the RSO or designee, and explain the failed condition(s).
9. If all checks pass, mark PASS, initial the DFSCL, and return form to designated in-use storage location. This may be a binder, folder, or cabinet. The instrument is now ready for use.
10. If the instrument will be used for routine personnel exit monitoring ensure the alarm threshold is set to alarm and actuates at a level below the site removable contamination limits identified in Table 6-1 of the Site Safety & Health Plan (SSHP). Make adjustments as necessary.

11. Ensure sources are stored properly after use in the designated source storage location.

10.4 Operations

1. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.

2. Evaluate the surface or area to be surveyed for potential scanning interferences. For example, thin layers of water or soil can prevent the detection of alpha contamination. Another example is the use of a NaI probe to qualify soil contamination. The presence of standing water can have a significant impact on instrument response. Initiate necessary corrective actions prior to survey or note conditions during survey reporting.

3. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degrees ranges, observe the following precautions:

    - Use particular caution with NaI crystals that may shatter under extreme temperature changes. If the temperature difference is greater than 30 degrees between storage and usage locations, wrap the probe tightly in a cloth towel or other insulator and allow warming or cooling over at least one hour prior to use.
    - Periodically check the instrument against a known source of radiation or contamination. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
    - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.

4. Protect instruments to the extent possible from exposure to moisture (i.e., rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.

5. Minimum Detectable Activities (MDA) for each survey should be determined by evaluating field background levels, not background values obtained during operational checks. Calculate MDA using the formula provided in PP-8-805, "Radiological Surveys."

6. Determining activity in disintegrations per minute (dpm) should be performed using the instrument efficiency obtained during calibration. Efficiencies are normally not established for NaI probes, and therefore should not be used for quantifying activity concentrations. The use of NaI probes for activity quantification shall be evaluated by the RSO prior to performance.

7. Observe the following when performing survey scans and static measurements:

    - Alpha probes should be held within ¼-inch of the surface being surveyed. Probe speed should not exceed 1 probe width per second.
    - Beta probes should be held within ½-inch of the surface being surveyed. Survey speed should not exceed one probe width per second.

- NaI probes should be held as close as possible to the surface being surveyed without contaminating the probe housing. Note that the crystal is located in the probe end opposite the cable connection. Use appropriate sleeving or wrapping in wet or dirty environments.
- The scan speed for performing Gamma Walkover Surveys is approximately 0.5 m/sec. Move the detector side to side using a 1-meter path length. Each side-side swing should take 2 seconds to traverse the 1-meter path. Advance the probe forward as you go at a rate of approximately 0.5 m/sec. Use the audio function. When increased counts are detected, slow down and locate the source as would be done in a normal survey. Walk parallel paths to ensure that 100% of the area is surveyed. Ensure that the survey extends to the boundaries of the survey unit. Pay particular attention to low lying areas, ditches, and points of possible contamination.
- Static measurements should be performed in any location were scans indicated the presence of activity. This is due to the fact that instrument MDAs are normally based on a 1-minute static measurement.
- All static measurements should be at least 1 minute, if the instrument has a scaler function. If the instrument is a ratemeter only, static measurements should last until the meter reading has fully stabilized.

8. Perform a post-operational check after use if directed by work plan, procedure, or the RSO.

11.0 ATTACHMENTS

Note: Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachments.

Attachment 1 Portable Instrument Set-Up Sheet (Typical)

Attachment 2 Daily Field Source Check Logsheet (Typical)

Attachment 1
Portable Instrument Set-Up Sheet (Typical)

PORTABLE INSTRUMENT SET-UP SHEET

Set-Up Location: ______________________

INSTRUMENT DATA			COUNT (n)	Source Counts	Source Count Time (min)	Source CPM	Background Counts	Background Count Time (min)	Background CPM	NET CPM
	INSTRUMENT	DETECTOR	1							
MODEL										
SERIAL #			2							
CAL DUE										
HV			3							
THRESHOLD										
SOURCE DATA			4							
ISOTOPE			5							
SERIAL #			6							
			7							
ACTIVITY (uCi)			8							
			9							
ACTIVITY (dpm)			10							

REMARKS	CALCULATED VALUES			ACCEPTABLE RANGES		
	Background (CPM)		Net CPM	Background (CPM)		Net CPM
		Average			+ 20 %	
					+ 3 Sigma	
		+/- Sigma			+ 2 Sigma	
					+ 1 Sigma	
		+/- 20 %			- 1 Sigma	
					- 2 Sigma	
					- 3 Sigma	
					- 20 %	

Performed By:	Date / Time:	Reviewed By:	Date / Time:

Attachment 2
Daily Field Source Check Logsheet (Typical)

DAILY FIELD SOURCE CHECK LOG

MONTH / YEAR: ______________________

INSTRUMENT DATA	INSTRUMENT	DETECTOR
MODEL		
SERIAL #		
CAL DUE		

SOURCE DATA	
ISOTOPE	
SERIAL #	
ACTIVITY dpm	

INSTRUMENT RANGES	Background	Net CPM
+ 20 %		
+ 3 Sigma		
+ 2 Sigma		
+ 1 Sigma		
- 1 Sigma		
- 2 Sigma		
- 3 Sigma		
- 20 %		

NET CPM CALCULATION
{B} - {A} = {C}

Date/Time	Physical	Battery	High Voltage	Audio	Background CPM {A}	Source CPM {B}	Net CPM {C}	PASS or FAIL	Tech. Initials

Remarks:	Reviewed by:

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<tr><td>TITLE:</td><td rowspan="3">Dose Rate Instruments</td><td>NO.:</td><td>RP-109</td></tr>
<tr><td></td><td>PAGE:</td><td>1 of 6</td></tr>
<tr><td></td><td>DATE:</td><td>May 2014</td></tr>
<tr><td colspan="4">APPROVED:

_____________________________ 5/31/14
Technical Services Manager Date

_____________________________ 5/31/14
Corporate Certified Health Physicist Date</td></tr>
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1.0 PURPOSE

This procedure specifies the methods for performing source checks and operating portable Gamma scintillation dose rate instruments, specifically, the Ludlum Model 12s uR and the Bicron Model Micro Rem. These instruments are used for the evaluation of exposure rates from radioactive materials and determining environmental radiation levels.

2.0 APPLICABILITY

This procedure addresses those instruments that measure dose rate from a scintillation detector and have displays that read in uR/hr, uRem/hr and/or mRem/hr such as Ludlum 12s, Bicron Micro Rem, or Eberline RO-2. Equivalent instruments that operate in a similar fashion to those identified in this section may be operated under this Project Procedure with RSO approval.

3.0 REFERENCES

1. ANSI N323-1978, Radiation Protection Instrument Test and Calibration.
2. Instrument Technical Manuals.
3. Perma-Fix Environmental Services (PESI) RPP

4.0 DEFINITIONS

None

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Reviewing and approving changes to this procedure and ensuring compliance with applicable regulations.
- Ensuring an adequate inventory of Radiation Protection instruments are available to support remediation activities.
- Overseeing the issue, control and accountability of Radiation Protection instrumentation per the requirements of this procedure.

- Ensuring transmittal of all issue, control and accountability records to the appropriate document control authority when applicable.

5.2 Radiation Protection Technician (RPT)

- Maintaining instrument documentation and records as required by this procedure.
- Maintaining adequate instrument and equipment availability.
- Verifying current calibration and response test dates prior to issue or use of instruments.
- Promptly returning instruments to their proper location when work is complete.
- Ensuring that instruments are properly surveyed for contamination and decontaminated as necessary, after use.

6.0 PREREQUISITES

- Only personnel with documented training shall issue or use RP instrumentation.
- Instruments and detectors shall be inspected for mechanical damage, and response tested prior to issue.
- Any instrument to be used shall have a current calibration label affixed to the instrument.

7.0 PRECAUTIONS AND LIMITATIONS

- Portable count rate survey instrumentations are susceptible to damage from physical and environmental stresses.

8.0 APPARATUS

- Survey instrument
- Tech source
- Source positioning device (jig)

9.0 RECORDS

- Daily Field Source Check Log – Exposure Rate Instruments (Attachment 1)
- Exposure Rate Instrument Set-Up Sheet (Attachment 2)

10.0 PROCEDURE

10.1 General

1. Ensure the instrument selected is within their acceptable calibration periods. This is indicated on an attached calibration sticker. Illegible stickers should be replace prior to instrument use.
2. The RP Group will coordinate instrument calibration on a minimum annual basis and after major repair operations. Battery change-outs do not require re-calibration. Calibration procedures are outside of the scope of this instruction.
3. Pre-operational source checks are required daily, or prior to each intermittent use, whichever is less frequent. Post-operational source checks are performed as specified in work plans or procedures. Instruments used in the performance of daily activities do not normally require a post-operational source check.

4. Instrument set-up and subsequent operational checks should be performed in the same location, with consistent temperature and radiation background levels.
5. Use a gamma check source with an activity sufficient to produce contact exposure rates at least ten times higher than background. Cs-137 is typically since it emits 662 keV gamma rays which are representative of the mid-range of gamma energies encountered at NFSS. Alternate sources may be used with RSO approval.
6. Source positioning devices (i.e., jigs) should be used to ensure a reproducible geometry between instrument checks. Source geometry must be consistent between initial instrument set-up and subsequent operational checks.
7. The Ludlum 12s may be operated in the FAST response mode. Switch to SLOW response for obtaining precise readings.
8. Internal scintillation crystals are orientated towards the front of the instrument. Meter cases have visible indicators showing optimum locations to obtain measurements (i.e. effective detector center).
9. Allow instrument readings to maximize prior to recording instrument reading. This may take up to twenty seconds. Note that the needle may not rest on a single value, but may fluctuate slightly between two points on the scale. If this is the case, an average reading should be obtained by summing these two end points and dividing by two.
10. Instruments should be allowed to warm-up for at least one minute prior to obtaining readings.
11. Report any abnormal instrument readings (e.g., unstable analog meter fluctuations), or background inconsistencies to the RSO, prior to continuing instrument use.
12. Instruments that fail operational checks or malfunction during use should be tagged or labeled "Out-of-Service," or "Do Not Use," and segregated from operational instruments. If possible, describe the problem on the tag / label and add initials and date.
13. Instruments leaving RPP Group control (i.e., repair, calibration, excess, etc.) shall be surveyed for unconditional release. The repair / calibration center may request a copy of the survey to accompany shipments of RP instruments.

10.2 Instrument Source Check

1. Obtain the selected instrument.
2. Obtain the corresponding Daily Field Source Check Log – Exposure Rate Instruments form, Attachment 1. This form will be referred to as the "Source Check Log." Initiate a new Source Check Log, if necessary.
3. Perform a physical inspection of the instrument. Place particular emphasis on the following items:
    - Instrument case is not visibly damaged beyond minor scrapes and scratches.
    - Analog display is not cracked or otherwise damaged.

- Switches and buttons are functional.
- Audio, if present, is functional.
- Calibration labels are legible and instrument is within calibration period.

4. Note results of physical inspection on the Source Check Log.
5. Verify the battery level is within the acceptable range on the analog display. Replace batteries and re-verify, as necessary.
6. Note battery check results on the Source Check Log.
7. Verify the high voltage (HV) level is within the acceptable range on the analog display, if present. Place the instrument out-of-service if the HV is outside the acceptable range.
8. Note the HV check results on the Source Check Log.
9. If acceptable background ranges have not been established, perform the following:
   - Obtain a blank NFSS Exposure Rate Instrument Set-Up Sheet, Attachment 2. This form will be referred to as the "Set-Up Sheet."
   - Record the basic source and instrument information at the top of the form.
   - Using the instrument and the source jig (without source), obtain and record ten background readings. The instrument should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained has stable background levels and is the location used for subsequent source checks.
   - Calculate and record the average background value and +/- 20% values on both the set-up and source check logsheets.
10. Obtain and record an average background reading on the source check log.
11. Compare the average background reading to the acceptable range. If background response is outside this range, report the condition to the RSO for evaluation, otherwise continue with source check process.
12. Obtain the source to be used for instrument source checks.
13. If acceptable source check ranges have not been established, perform the following:
   - Obtain the Set-Up Sheet used to determine acceptable background ranges for the instrument.
   - Using the instrument and the source jig (with source), obtain and record ten contact source readings. The instrument and source should be removed from the source jig and repositioned after each reading is obtained. Make sure the location where readings are obtained is the same location where previous background readings were obtained.
   - Calculate and record the average source value and +/- 20% values on both the set-up and source check logsheets.

14. Load the source and instrument onto the source jig.
15. Obtain and record the "CONTACT" reading.
16. Verify the contact reading is within the acceptable range (+/- 20%).
17. If the contact source reading falls outside the acceptable range, tag the instrument out of service and notify the RSO, otherwise continue.
18. Complete the source check log including technician initials. The instrument is now ready for use.
19. Ensure sources and forms are stored properly after use in the designated storage location. Forms are retained in RP Instrument logbooks of field files during instrument use (i.e. calibration) cycle. Records are then reviewed by the RSO, or designee for completeness and forward to Project Records for retention.

10.3 Operations

1. Verify that required source checks have been performed prior to initial instrument use.
2. Operate instrument in a manner that minimizes the potential for cross-contamination and physical damage.
3. Limit readings taken while the instrument is positioned sideways to minimize the effects of "geotropism" on the analog needle.
4. Obtain readings by positioning the instrument as close to the detector's "effective center" as possible. The detector effective center is represented on the instrument housing a cross inside a circle on the Bicron Micro Rem, and a small circular depression on the Ludlum 12s. Overall optimum readings are collected from the front of the instrument housing.
5. Most instruments will operate in temperatures between 10 and 120 degrees Fahrenheit. However, anytime the temperature is outside of the 32 degree (freezing) or 100 degree ranges, observe the following precautions:
   - Be observant of instrument response to background. If the instrument begins to show a decreased response to expected background levels contact the RSO, or designee for guidance.
   - If practicable, perform a period response check of the instrument against a known source of radiation. If the instrument appears to be responding incorrectly contact the RSO or designee for guidance.
   - Contact the RSO for guidance anytime work is planned outside of the 10 to 120 degree range.
6. Protect instruments, to the extent possible, from exposure to moisture (i.e. rain, snow, etc.) during use. Instruments shall be stored in a safe manner when not in use.
7. Perform a post-operational source check after use, if directed by work plan, procedure, or the RSO.

11.0 ATTACHMENTS

Attached forms are examples and may be modified by the RSO, as needed, without revision to this procedure.

Attachment 1 Daily Field Source Check Log – Exposure Rate Instruments (Typical)

Attachment 2 Exposure Rate Instrument Set-Up Sheet (Typical)

Attachment 1

Daily Field Source Check Log – Exposure Rate Instruments (Typical)

FMSS DAILY FIELD SOURCE CHECK LOG
- EXPOSURE RATE INSTRUMENTS

MONTH / YEAR: ____________________

INSTRUMENT DATA	
	INSTRUMENT
MODEL	
SERIAL#	
CAL DUE	
HV	

SOURCE DATA	
ISOTOPE	
SERIAL #	
ACTIVITY uCi	

INSTRUMENT RANGES		
	Background	Contact Source
+ 20 %		
- 20 %		

Units (Circle One

uR urem mR mrem R rem

Date/Time	Physical	Battery	High Voltage	Audio	Background	Contact Source	PASS or FAIL	Tech. Initials

Remarks:

Reviewed by:

Attachment 2
Exposure Rate Instrument Set-Up Sheet (Typical)

FMSS EXPOSURE RATE INSTRUMENT SET-UP SHEET

Set-Up Location: ______________________

INSTRUMENT DATA		READING (n)	Background Rate	Contact Source Rate	CALCULATED AVERAGE AND RANGES		
	INSTRUMENT	1			Background		Contact Source
MODEL		2				Average + 20%	
SERIAL #		3				Average	
CAL DUE DATE		4					
HV		5				Average - 20%	
SOURCE DATA		6			**Units (Circle One)**		
ISOTOPE		7			**uR urem mR mrem R rem**		
SERIAL #		8			**REMARKS**		
		9					
ACTIVITY (uCi)		10					

Performed By:	Date/Time:	Reviewed By:	Date/Time:

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Radioactive Materials Control and Waste Management Program	NO.: RP-111
	PAGE: 1 of 6
	DATE: March 2017

APPROVED:

Technical Services Manager — Date: 03/03/17

Corporate Certified Health Physicist — Date: 03/03/17

1.0 PURPOSE

This procedure provides guidance and requirements for the control of radioactive materials including the management of radioactive waste. The Radioactive Materials Control and Waste Management Program applies to the receipt, inventory, storage and handling of radioactive materials; the release of materials from Restricted Areas; the control of radioactive sealed sources; the control of materials and contaminated tools and equipment entering and/or leaving Restricted Areas; and the management of waste including transportation and disposal.

2.0 APPLICABILITY

This procedure applies to all PESI Project personnel and all decommissioning projects that involve radioactive materials. This procedure does not apply to the monitoring of liquid and gaseous effluents, radiological environmental monitoring, or final termination surveys of the reactor or facilities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Radiation."
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
5. 49 CFR, Subchapter C "Transportation – Hazardous materials Regulations"

6. 40 CFR, Subchapter I "Solid Wastes"
7. 40 CFR Part 260-273 "Hazardous Waste Management System"
7. USNRC Circular 81-07, "Control of Radioactively Contaminated Materials."
8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, "Radiological Posting Requirements."
11. RP -104, "Radiological Surveys."
12. RP- 105, "Unrestricted Release Requirements."
13. RP -114, "Control of Radiation Protection Records."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Aggregate Material: Items or materials that by their physical nature do not lend themselves to being effectively surveyed using portable instrumentation and require bulk or composite survey techniques or representative sampling and analysis.

Conditional Release of Material: Items or materials that do not meet unconditional release criteria and that are released under the control of Radiation Protection personnel.

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Unconditional Release of Material: Release of equipment or material to the general public. The equipment and / or material are deemed to meet site release criteria for both total and removable contamination.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Ensuring adequate staffing, facilities and equipment are available to perform the radioactive material control functions assigned to Radiation Protection personnel.
- Investigating and initiating corrective actions for the improper handling of radioactive material.
- Approving purchase or acquisition of radioactive sources.
- Ensuring a source inventory and leak testing program is established.
- Authorizing the establishment of radioactive material and sealed source storage locations.
- Packaging and transferring radioactive material to appropriate authorities.
- Administering receipt / release survey programs of radioactive material.
- Administering radioactive source inventory and leak testing.
- Ensuring correct posting of radiological area.
- Reviewing results of sample analysis and survey data as required to determine acceptability for release of items.
- Ensuring packages for transport and disposal meet applicable regulations for integrity and dose limits.

5.2 Certified Waste Shipper

The certified (as required by 49 CFR 172, Subpart H) waste shipper is responsible for:

- Identifying proper packaging and posting requirements for all offsite transport of radioactive and/or mixed wastes.
- Reviewing results of conveyance package radiation surveys and performing inspections of conveyance packages prior to approving packages to leave a site.
- Maintaining records of all waste shipments.
- Assisting the RSO in proper characterization, classification and sampling of any potentially radioactive or mixed waste
- Selecting the treatment, storage and disposal facility (TSDF) to be used for processing, treatment, and/or disposal of radioactive or mixed waste
- Preparing profiles and shipping paperwork for disposal of radioactive or mixed wastes generated
- Directing and performing inspections, marking, labeling and placarding of radioactive or mixed waste prior to shipment
- Selecting the proper packages to use for radioactive or mixed waste
- Maintaining an inventory of radioactive and mixed waste onsite and shipped off the project.
- Ensuring periodic inspections as required by regulation are performed and documented

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Performing and documenting radiation and contamination surveys, inspections and leak tests.
- Posting, securing, and controlling radioactive material and source storage areas.
- Safely opening packages of radioactive material.
- Identifying radioactive material.
- Releasing material in accordance with this and implementing procedures.
- Notifying the RSO or designee on arrival of radioactive material.
- Performing pre-transportation surveys of radioactive materials packaging and conveyance vehicles.

5.4 Project Personnel

Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Obtaining RSO authorization prior to accepting receipt of radioactive material at the project. This includes, but is not limited to items such as sealed sources, liquid standards, and contaminated equipment from other sites, and waste generated outside normal project remediation activities. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
- Complying with direction from RP personnel regarding the proper methods for receipt, handling, decontamination, packaging, storage, transport and disposal of radioactive material.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

Packages of radioactive material or sources shall NOT be opened until the required receipt survey is performed by RP personnel.

Packages of radioactive waste shall not leave a site until approval to do so is granted by the Certified Waste Shipper.

8.0 RECORDS

- Receipt radiological surveys
- Radiological release surveys
- Radiological transportation surveys
- Source Inventory which includes Leak Test Results
- Transportation records including manifests, transportation checklists, and a transportation log

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

9.1 Receipt of Radioactive Material

1. Obtain RSO authorization prior to accepting receipt of radioactive material at the project.
   - Radioactive materials which may be received include, but are not limited to, items such as sealed sources, liquid standards, contaminated equipment from other sites, waste generated outside normal project remediation activities and shipments of radioactive materials from vicinity properties to the PESI for storage and / or transportation and disposal. This is to ensure that required receipt surveys are scheduled, appropriate ALARA considerations are implemented, and that the source term is evaluated for possible effects to the project waste stream criteria.
   - Refer to 10 CFR 71.4 and Appendix A to 10 CFR 71 for definition and limits for "Type A Quantities" of radioactive materials.
   - The RSO may direct receipt surveys to be performed on any incoming radioactive material shipment.
2. If an expected package exceeds Type A quantities, the package requestor shall make arrangements with RP and the carrier to receive or pick-up the shipment when the carrier makes notification of package availability.
3. RP personnel perform receipt inspections and surveys of incoming radioactive material shipments which exceed a Type A quantity (refer to 10 CFR 71.4 and Appendix A of 10 CFR 71) as follows:
   - The inspection and survey shall be performed within three hours of receipt. If received after normal work hours, the survey is required with three hours from the beginning of the next business day.
   - Don latex gloves, at a minimum, when performing incoming inspections and surveys.
   - Inspect the package for leaks or apparent damage.
   - Ensure the contents match the packing slip or shipping papers.
   - Perform a radiation survey of the package exterior.
   - Perform a removable contamination survey of the package interior and exterior.
4. RP Personnel shall store the package in a secure, radiologically posted area, notify the RSO or designee if any the following conditions are observed during receipt of a radioactive material shipment:
   - Contents do not match packing slip or shipping papers
   - The contents of the package do not contain the isotopes or quantities of material as ordered or expected.
   - Package is leaking or sufficiently damaged to compromise package contents.
   - The receipt survey results exceed any of the following limits:
   - Radiation (mrem/hr) – 200 @ Contact or 10 @ 1 meter from the package
   - Removable Contamination (dpm/100cm2) – 2200 Beta-Gamma, 220 Alpha

9.2 Identification of Radioactive Material

1. Radioactive material exceeding limits specified in 10 CFR 20, Appendix C shall be identified and labeled by Radiation Protection personnel:
   - On receipt of packages containing radioactive material or sources.
   - During removal of items or material from contaminated systems or areas, or from radioactive materials areas.
   - In the course of performing area and job specific surveys.
   - In the course of surveying items for release.
2. Items that meet or exceed the contamination limits established in the PESI RPP should be labeled radioactive material.
3. Use the following guidance, as a minimum, when labeling radioactive material:
   - Labels shall only be placed or removed by Radiation Protection personnel.
   - Unique features (e.g., yellow plastic bags, yellow and magenta tags, purple paint, etc.) should be used to clearly identify the physical and radiological parameters of the material.
   - Labeling shall state "CAUTION - RADIOACTIVE MATERIAL."
4. Exceptions to labeling requirements for radioactive material are as follows:
   - The item or material is under the direct control of personnel who are aware of the contents and the associated radiological hazards.
   - The material is radiation protection equipment (e.g., respirators, instruments. etc.).
   - The material consists of radiological samples being analyzed or sampling equipment controlled by Radiation Protection personnel.
   - The material is packaged and labeled in accordance with DOT regulations while awaiting transport.
   - The material is contained in permanently installed equipment and / or potentially contaminated systems.
   - The material consists of permanently installed equipment or components, including check sources installed in radiation monitoring equipment, which have manufacturer supplied check source labels affixed. Radiation level posting requirements shall remain applicable.
   - The material consists of laundered protective clothing:
     a. In controlled use, inside the Restricted Area; or
     b. Stored in designated laundry containers.
   - The material consists of check sources or sealed sources and source storage containers identified as radioactive material with identifiable labels affixed to the source.

- The material is stored or in-use in a posted Contamination Area or Airborne Radioactivity Area. All items in these areas are considered potentially radioactive/contaminated until properly dispositioned by RP personnel.
- The material consists of contaminated items (e.g., hand tools) impractical to label, that are marked with magenta paint.

5. Project personnel should notify Radiation Protection of any items or containers with lost or damaged radioactive material labels.
6. Material requiring labeling as radioactive material which is found uncontrolled and outside a Restricted Area shall be brought to the immediate attention of RP Personnel.

9.3 Storage of Radioactive Material

1. Radioactive Material Storage Areas shall be posted in accordance with RP -102, "Radiological Posting Requirements."
2. Radiation Protection personnel should consider the following when specifying radiological requirements for Radioactive Material Storage Areas:
    - Changes to radiation levels in an area as a result of material storage.
    - External environmental conditions are such that significant container degradation does not occur during storage.
    - Material is adequately packaged and controlled to minimize the potential for loss of radioactive material control
3. Unsealed radioactive materials e.g. soil, debris, liquids will be posted and controlled in accordance with RP-102, Radiological Posting Requirements.
4. Soil, debris, and materials will be staged in appropriate containers/bags or covered with tarps as necessary to prevent migration outside of radiological boundaries.
5. Liquids will be stored in appropriate containers (e.g. drums, totes, etc.)
6. All storage containers will be labeled with pertinent information including description and radiological data.
7. PPE requirements for handling radioactive materials are established in the applicable RWP and procedure RP-132, *Selection and Use of Radiological PPE.*

9.4 Special Considerations for Control of Accountable Radioactive Sources

1. The RSO, or designee shall serve as the Source Custodian and shall be responsible for the following:
    - Ensuring that all accountable radioactive sources are stored in their designated storage location when not in use.
    - Maintaining a source inventory that includes accountable source identification, isotopic content, activity, assay date, designated storage location, and date and results of most recent semi-annual leak test.

2. Any individual planning to procure a radioactive source for the project shall request approval from the RSO in writing. This request shall include a justification for bringing additional sources onto the project and shall include all necessary source information to update the source inventory.
3. Licensed sources under the control of a licensee (e.g., radiography sources, soil density gauges, etc.) are not maintained in the project accountable source inventory. Project personnel requesting such vendor services shall ensure that the RSO receives evidence of the following prior to source mobilization to the project:
   - Source license including isotope and source activity
   - Semi-annual leak testing performed by the licensee
4. Source Custodian, or designee shall ensure that a leak test is performed and documented for any accountable source in inventory under any the following conditions:
   - Upon source receipt in inventory
   - Semi-annually
   - Prior to transfer to a new permanent storage location
   - Prior to disposal
   - If source integrity is compromised
5. A source leak test consists of a physical source inventory, a visual inspection for source integrity and a contamination survey capable of detecting the presence of 0.005 microcuries (200 Bq) of removable radioactivity.
6. If direct contact with the source is impractical (i.e., inaccessible, unsafe from an ALARA standpoint, or could potentially compromise source integrity) the source container or storage location may be surveyed as representative of the leak test.
7. All accountable sealed radioactive sources or their individual storage containers shall bear a durable label or tag which includes the following minimum information:
   - Source Identification
   - Radionuclide(s)
   - Source Activity
   - Assay Date
   - Source Custodian Name and Contact Number
8. The RSO shall establish designated locations for the storage of accountable radioactive sources using the following guidance:
   - Sources should be stored in a lockable location
   - Sources should be stored to minimize exposure to fire or combustible materials
   - Sources should be stored in such a manner to minimize radiation exposure to personnel routinely present in the area.

9.5 Movement of Radioactive Material

1. Radioactive material or contaminated material shall be properly contained before moving to minimize radiation levels and prevent spread of contamination.
2. Obtain direction from the Project Transportation Specialist and / or the RSO prior to transporting radioactive materials across public highways or railroads regulated by the Department of Transportation. Transport shall be performed in accordance with this procedure and all applicable local, state, and federal regulations.

9.6 Control of Tools, Equipment and Material

1. All items to be released from radiological controls shall be surveyed by RP personnel.

2 The RSO may authorize the establishment of "Hot Tool" storage areas for reusable contaminated tools, components, equipment and material. If labeling of these items (e.g., hand tools) is impractical, magenta paint may be used to identify the item as radioactive material.

3. Project Management should ensure that adequate supplies of clean and "hot" tools are available project personnel. This maximizes worker effectiveness in radiological areas, minimizes survey and decontamination efforts, and reduces radioactive waste generated.
4. Radioactive waste receptacles will be established and maintained for the disposal of items.

9.7 Release of Items from Radioactive Material Controls

1. RP personnel shall perform surveys to release items from radioactive material controls, with the following exception:
    - Hand-carried items (e.g., pens, paper, flashlights, logbooks, clipboards, safety glasses, dosimetry, badges, etc.) under a single individual's control and that are not expected to have come into contact with potentially contaminated surfaces may be monitored by that individual during the personnel frisking process.
2. RP personnel will survey items designated for unrestricted release according to RPP-105, "Unrestricted Release of Equipment."
3. RP personnel shall ensure the labeling is appropriate and direct Project personnel as how to best disposition the item (i.e., decontamination, packaging, storage, or disposal as radioactive waste) if an item is contaminated and cannot be released for unrestricted use.
4. RP personnel shall ensure that any labeling or marking identifying the item as radioactive material is removed or thoroughly defaced if the release survey indicates that the item may be released for unrestricted use.

9.8 Transportation and Disposal of Radioactive Waste

1. Characterization sampling and analysis of waste for radioactive and hazardous constituents shall be performed to ensure waste meets the selected waste facility's Waste Acceptance Criteria.
2. Waste which is considered "decommissioned waste" (waste with residual radioactivity distinguishable from background regardless if it meets alternative requirements for unrestricted release) shall not be disposed of in a Class III California land fill or in a California unclassified waste management unit in accordance with California Executive Order D-62-02.
3. Packaging of waste shall be commensurate with the radionuclide(s) activity and the physical form of the waste in accordance with 49 CFR 178.350 (if applicable).
4. Labeling and placarding of waste packages shall be performed in accordance with 49 CFR 178.350 (if applicable).
5. Radiation surveys shall be performed on waste packaging and/or conveyance vehicles. These surveys shall include dose rates as required by 49 CFR 173 and offsite transportation shall not be permitted if applicable dose limits are exceeded.
6. A transportation inspection shall be performed and documented on the "Transportation Checklist Form" (**Attachment 1**) prior to waste shipments leaving a site.
7. Proper shipping paperwork shall be completed and shall accompany all transports of radioactive waste.
8. Emergency response guidance and contact information shall be provided to all conveyors of radioactive waste (refer to **Attachment 2**).
9. Records of waste disposal shall be maintained sufficient to meet the requirements of CDPH 5314 (to support eventual license termination). Information required includes inventory of waste, dates of transfer, and recipient information. These records should be maintained even if license termination is not the immediate goal of a project.

10.0 ATTACHMENTS

1. Transportation Checklist Form
2. Emergency Response Instructions

Attachment 1

Transportation Checklist Form

TRANSPORT VEHICLE INSPECTION CHECKLIST

Shipment No.	Carrier DOT Hazmat Registration No. / Exp. Date		
Carrier Name:	Tractor No.		Trailer No.
Drivers Name:	State:	License No.	Exp. Date

	ITEM	STATUS Pre Load		STATUS Post Load		CRITERIA
		SAT	UNSAT	SAT	UN SAT	
1	Operator's License					Driver possesses a valid commercial driver's license (with a tank vehicle or hazardous materials endorsement) to operate the vehicle
2	Windshield, Side Glass and Mirrors					No cracked or broken glass that would affect the vision of the driver. Mirror(s) in place and usable
3	Wipers					Wipers operate and are in good condition
4	Horn					Air/electric horn(s) work
5	Suspension					Visually check for loose, broken, or damaged spring leaves, "U" bolts, shackles. Pads, torque arms, and locking pins
6	Brake Lines					Brake lines and connectors do not have cracks, crimps, restrictions, or evidence of damage or audible air leaks
7	Brake Pots, Cams					Brake pots are in good physical condition and mechanical linkages are intact and in good condition
8	Exhaust System					No loose or broken brackets and no evidence of leaks which would affect driving/sleeping compartment
9	Fuel System					No visible damage affecting fuel tank integrity, no visible leaks, no loose or broken mounting brackets, no evidence of damage to vents, and fuel cap is securely in place
10	Structure, Welds					No visible significant cracks in major welds
11	Frame					No cracked, loose, sagging, or broken frame
12	Trailer Floor					No holes or projecting nails. Capable of bearing weight of load and fork truck (if used)
13	Trailer Walls					No holes, severe dents or buckling
14	Trailer End Gate					Can be closed and secured properly
15	Rims					Rims are not bent or cracked and stud nuts are in place
16	Tires					Tires appear properly inflated, tread depths appear greater than minimum (tread depth at least 1/8" on front and 1/16" on all others) and show no evidence of cuts or damage affecting the ply cord
17	Hubs					No visible oil leakage from seals
18	Head Lights					Both low beams working
19	Running Lights					All affixed running lights operable
20	Turn Signals					Front and back working
21	Brake Lights					Must work on tractor and trailer
22	Liner					Insure liner is properly installed
23	Cleanliness					No amount of material from the site on external surfaces of the conveyance.

PRE-LOAD INSPECTION	**(Printed Name, below)**	**(Signature, below)**
INSPECTION DATE:		
POST-LOAD INSPECTION	**(Printed Name, below)**	**(Signature, below)**
INSPECTION DATE:		
Comments:		
REVIEWED BY:	**(Printed Name, below)**	**(Signature, below)**
REVIEW DATE:		

RP-111 Radioactive Materials Control and Waste Management Plan

Attachment 2

Emergency Response Instructions

EMERGENCY RESPONSE INSTRUCTIONS

Manifest No.: ______________________

EMERGENCY PHONE NUMBER:

MATERIAL DESCRIPTION:

IMMEDIATE ACTIONS:

RENDER FIRST AID TO INJURED PERSONS

SECURE THE IMMEDIATE AREA

REPORT THE EMERGENCY

FIRST AID:

Use First Aid according to the nature of the injury
Do not delay care and transport of a seriously injured person
Advise medical personnel that injured persons who may have contacted spilled material may be contaminated with low level radioactive material

SECURE THE IMMEDIATE AREA:

Keep unnecessary people at least 160 feet away in all directions and upwind of shipment
Fight small fires with portable extinguisher, *if safe to do so*
Isolate the area and deny entry to unnecessary personnel

REPORT THE EMERGENCY:

Contact the applicable Emergency Phone Number listed at the top of this page.

APPROVED:

Technical Services Manager 5/31/14 Date

Corporate Certified Health Physicist 5/31/14 Date

1.0 PURPOSE

This procedure provides consistent methodology for the issuance of radiation monitoring dosimetry devices at Perma-Fix Environmental Services (PESI) facilities and projects.

2.0 APPLICABILITY

This procedure applies to all Safety and Health personnel issuing dosimetry devices.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."

4.0 GENERAL

4.1 Discussion

This procedure describes the requirements for the issuance of standard dosimetry devices to visitors and radiation workers accessing restricted areas of the remediation project.

The Thermoluminescent Dosimeter (TLD) normally provides the dose of record, while the Self-Reading Dosimeter (SRD) provides a means of deep dose tracking prior to TLD processing, as well as verifying the reasonableness of the results

4.2 Definitions

Radiation Worker: An individual who accesses any Radiological Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Radiological Areas.

Radiological Area: Any area within a Restricted Area which require posting as a Radiation Area, Contamination Area, Airborne Radioactivity Area, High Contamination Area, or High Radiation Area.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

Self-Reading Dosimeter (SRD): A radiation monitoring device (either electrostatic or electronic) that can be read by the wearer at any time and indicates total accumulated dose.

Thermoluminescent Dosimeter (TLD): An integrating detector where radiation energy is absorbed (trapped) and can be read out later by thermal excitation of the detector (ANSI N13.15-1985).

Visitor: An individual who accesses the project site for purposes other than working (e.g., tour the site or meet with an individual).

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- The RSO is responsible for implementing this procedure.

5.2 Radiation Protection Technicians (RPTs)

- RPTs are responsible for the performance of this procedure.

5.3 Project Personnel

- Provide the RP Dosimetry Group with required personal information to track and report radiation exposures (e.g., Social Security/ID Number, Address, Date of Birth, Exposure History from Other Sites, etc.)
- Complying with Radiation Protection Program (RPP) requirements, including dosimetry care & use requirements identified in Attachment 1.

6.0 PREREQUISITES

Individuals who are planning to visit other radiologically monitored facilities while being monitored at PESI shall notify RSO prior to going to the other monitored facility(s).

7.0 PRECAUTIONS AND LIMITATIONS

- The NRC Form-4 for individuals with current year recorded or estimated exposures from other site(s) shall be reviewed by the RSO prior to issuance of dosimetry. The purpose of this review is to ensure that individuals would not exceed the quarterly exposure limit of 1.25 rem, or the annual exposure limit of 5 rem Total Effective Dose Equivalent.
- Any individual entering a Restricted Area, or performing work under a Radiation Work Permit shall wear dosimetry.
- TLDs will be changed out on a quarterly basis.
- Employee personal information shall be accessible only to personnel authorized by the RSO, SSHO, or Project Manager.

8.0 APPARATUS

- Self-Reading Dosimeters
- Thermoluminescent Dosimeters

9.0 RECORDS

- Occupational External Radiation Exposure History (NRC Form-4)
- TLD Issue Form (e.g., TLD Processor Chain-of-Custody)
- TLD Use & Care Acknowledgement

10.0 PROCEDURE

10.1 Dosimetry Issuance for Visitors

- Dosimetry is issued to escorted visitors accessing Restricted Areas, and as required by the RSO.

10.2 Dosimetry Issuance for Radiation Workers

1. Ensure that Radiation Worker Training has been successfully completed by the worker prior to dosimetry issue.
2. Ensure the individual has completed an NRC Form 4 "Occupational Radiation Exposure History."
3. Ensure the individual has completed the "TLD Use & Care Acknowledgement" form.
4. Ensure the worker understands the administrative dose limit and the fraction remaining (available dose) for the current year.
5. Review all other paperwork for completeness and legibility.
6. Issue a TLD to the individual by recording the pertinent information on the TLD Issue Form.

11.0 ATTACHMENTS

Attachments may be revised without formal review of this procedure and are attached as examples only. Please contact the RSO for a current copy of these attachment(s).

Attachment 1 Dosimetry Care & Use Acknowledgement Form

Attachment 1

DOSIMETRY CARE & USE ACKNOWLEDGEMENT

1. Use **only** dosimetry specifically issued to you.

2. Verify that you are wearing the appropriate dosimetry **prior** to entering Restricted Areas.

3. Unless otherwise directed by the RSO, Dosimetry **shall** be worn facing out, and attached to clothing/lanyard on the front of the upper torso. **Do not** attach dosimetry to waist belt loops, safety glasses, or hard hats.

4. Dosimetry **shall** be stored in the designated location during non-work periods.

5. Dosimetry **shall** not be worn off-site or to another radiological facility unless specifically authorized by RSO.

6. If dosimetry is misplaced or damaged, **perform** the following:

   a. Place work in a safe condition and exit the radiological area;
   b. Report the lost dosimeter to RP Personnel;
   c. RP shall initiate a Radiological Occurrence Report (ROR); and
   d. Obtain RSO authorization to issue replacement dosimetry.

7. **Do not** tamper with or expose dosimetry to excessive heat, security x-rays, or medical radiation sources. Report instances of tampering or unnecessary exposure to the RSO immediately.

Dosimetry is used to monitor your exposure as required by Federal Law and Company Policy. Failure to comply with these or other Radiation Protection Program requirements implemented for your safety, and for the protection of the public and environment may result in revocation of RadWorker Training credentials and Restricted Area access privileges.

I have read and understood the information presented and will comply with Radiation Protection Program requirements as established in the FMSS Site Safety & Health Plan.

______________________________ Signature

________________________ Date

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE: Control of Radiation Protection Records	NO.: RP-114
	PAGE: 1 of 6
	DATE: May 2014

APPROVED:

5/31/14
Technical Services Manager Date

5/31/14
Corporate Certified Health Physicist Date

1.0 PURPOSE

This project procedure defines the requirements for controlling Radiation Protection Program records. It also establishes the requirements for review and temporary storage of these records at PESI Sites prior to transmittal to Document Control.

2.0 APPLICABILITY

The requirements of this procedure are applicable to records generated by the Radiation Protection Group, and apply to all documents considered to be records.

3.0 REFERENCES

1. 10 CFR 20 "Standards for Protection Against Radiation."
2. PESI, "Radiation Protection Plan (RPP)

4.0 DEFINITIONS

Non-record: Non-record material includes those classes of documentary or other material that shall be disposed of without archival authority. Examples are copies of records transmitted to Document Control, paper copies of e-mail, and informal notes.

Records: For the purpose of this procedure, records shall be interpreted as radiation protection records. A record is considered to have been "generated" when it has been completed, signed (or initialed) by the generator, and completed required reviews. Examples of records are all survey forms and original Radiation Work Permits (RWP).

Retention Period: The period of time that a record may be retained by the Radiation Protection Group, prior to transmittal to Document Control.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Implementing this procedure, and performing oversight activities to ensure compliance with the requirements of this document.
- Establishing an RP Record Retention Schedule.
- Ensuring adequate storage space and personnel are available to perform Records Management activities.

5.2 Radiation Protection Records Coordinator (RC)

- Acts as the departmental contact for records.
- Ensures that records are adequately controlled according to this procedure.
- Ensures that records are transmitted to Document Control in a timely fashion, as defined by this procedure.

5.3 Radiation Protection Technicians (RPT)

- Complying with the requirement for this procedure.
- Protecting records in their possession from loss or damage.

6.0 PROCEDURE

6.1 Radiation Protection Group Functions

6.1.1 All personnel assigned to the group shall control records in accordance with applicable requirements of this procedure beginning when a record is first generated.

6.1.2 Records shall be prepared in accordance with Project Procedures. Preparation of these documents shall conform to the following:

Document content, including signatures, shall be:

- Legible and reproducible
- Appropriate for the particular activity performed
- Complete per the applicable requirements
- Traceable to the activity or item to which it applies

6.1.3 If records are damaged (i.e., torn, lost, illegible, or incomplete), action shall be taken and documented to ensure that re-created records are as complete and accurate as possible. Re-created records shall be identified as copies and be signed and dated by the generator.

6.2 Records Coordinator (RC)

6.2.1 The Radiation Protection RC shall:

- Ensure that all records received for transmittal are included on the Record Retention Schedule. The RSO should be notified if any record is not on the schedule.
- Review the records for acceptability by ensuring the content of the record complies with this procedure. The RC shall review each record ensuring that the record is legible, complete, signed and dated, and that the record contains sufficient information to fulfill the intended purpose of the record.

NOTE: The RC is not responsible for the technical adequacy or correctness of the record.

- Coordinate appropriate corrective action with the RSO when the condition of the records is not acceptable.
- Transmit records according to Document Control
- Prepare a document transmittal form, attach the completed form to the documentation package, and forward the records to Document Control.
- Retain a copy of the returned document transmittal form, which documents transmittal to Document Control.
- Maintain a Records Retention Schedule, approved by the RSO and provide a copy to Document Control.

6.3 Control of Records

6.3.1 Records shall be controlled and properly maintained from the time the record is generated until it is transmitted to Document Control

6.3.2 Records shall be stored in a controlled environment that protects the records from damage (i.e., winds, floods, fires, high and low temperatures and humidity and infestation of insects, mold, or rodents).

6.3.3 Each record shall be reviewed by the RSO to ensure that:

- The record contains sufficient information to fulfill the intended purpose of the document.
- The content of the record is accurate and complete.

6.3.4 Records monitoring transmittal to Document Control shall be stored in a 1-hour fire-rated container, if possible.

6.3.5 Storage facilities or cabinets with confidential information should be locked when unattended. Storage facilities for other document should be locked when unattended as is practicable.

6.3.6 Records that are in the process of being generated may be controlled by electronic storage, provided there is data back-up available.

6.3.7 Following transmittal, Document Control shall review the documentation to ensure that it is complete as indicated on the transmittal form, sign and date the transmittal form signifying receipt of the record package, and return a copy of the signed and dated form to Radiation Protection RC.

7.0 ATTACHMENTS

None

<table>
<tr><td colspan="2"></td><td colspan="2">PERMA-FIX ENVIRONMENTAL SERVICES</td></tr>
<tr><td>TITLE:</td><td rowspan="3">Radiation Worker Training</td><td>NO.:</td><td>RP-115</td></tr>
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<tr><td></td><td>DATE:</td><td>May 2014</td></tr>
<tr><td colspan="4">APPROVED:

_______________________________ 5/31/14
Technical Services Manager Date

_______________________________ 5/31/14
Corporate Certified Health Physicist Date</td></tr>
</table>

1.0 PURPOSE

The purpose of this procedure is to provide consistent methodology for implementing Radiation Worker Training (RWT) at Perma-Fix Environmental Services, Inc. (PESI) Sites.

2.0 APPLICABILITY

RWT is applicable to ALL PESI employees and subcontractors who perform work within Restricted Areas.

3.0 REFERENCES

- 10 CFR 19, "Notices, Instructions and Reports to Workers: Inspections and Investigations."
- 10 CFR 20, "Standards for Protection against Radiation."

4.0 GENERAL

4.1 Discussion

Successful completion of the RWT will qualify employees for unescorted access into Restricted Areas, provided other access requirements are met as specified in procedure RP-101, "Access Control".

Qualified individuals with a demonstrated knowledge of radiological concepts should provide RWT instruction. The RSO approves RWT Instructors.

4.2 Definitions

Controlled Area: An area under the control of PESI management area to which access is limited by Project Management.

Practical Factors: The "performance-based" portion of RWT that focuses on demonstration and evaluation of safe radiation worker practices. Particular emphasis is given to the donning and doffing of protective clothing and self-monitoring for radioactive contamination.

Radiation Worker: An individual who accesses any Restricted Area unescorted. Radiation Workers shall have successfully completed all requisite medical and training requirements for performing work in Restricted Areas as specified this procedure.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

The RSO is responsible for implementation of this procedure and approval of course content and materials.

6.0 PREREQUISITES

Prior to obtaining RWT qualification, individuals shall have submitted evidence of completion of other medical / training requirements established in the PESI Site Safety & Health Plan.

7.0 PRECAUTIONS AND LIMITATIONS

- RWT shall be required on a bi annual basis. Active site personnel may be granted up to a 90-day extension beyond the RWT anniversary date, with RSO approval.
- Individuals must have documented evidence of completing both academic and Practical Factors objectives before being allowed to work unsupervised in a Restricted Area.
- Personnel may be allowed to challenge the academic examination portion of this training by passing the examination.
- Bi-Annual re-qualification of the Practical Factors portion of RWT may be by observation of actual work practices.
- A minimum passing score on the RWT exam and Practical Factors is 80%.
- Trained emergency response personnel (Fire Department, Ambulance/EMT, Law Enforcement) responding to on-site emergencies are exempt from this training.
- The RSO may waive the classroom portion of RWT provided the individual is able to show documented proof of successful completion of an equivalent level of training from another facility during the previous 12-month period.
- RP technicians are exempt from this training.

8.0 APPARATUS

None

9.0 RECORDS

The Site Safety & Health Group shall maintain a copy of the RWT certificate or attendance roster in each employee file.

10.0 PROCEDURE

10.1 RWT Classroom Training

A. At a minimum, the following topics shall be discussed during RWT:

- Fundamental of Radioactivity
- Prenatal Exposure Risks
- Shaw Group Radiation Protection Plan
- Site Specific Radiological Hazards / contaminants
- ALARA Concepts
- Radiological Postings / Barriers
- Emergency Response / Evacuation Routes

B. Provide the trainees with a copy of the course materials and all pertinent training forms.

C. Present the course material including overhead slides.

D. Lecture on the associated concepts.

E. Answer any questions the trainees may have.

F. Review the material with the trainees prior to administering the exam.

G. Administer the RWT exam.

H. The proctor will grade the test and review incorrect answers with the trainee.

I. Submit the completed exam to RP Document Control.

10.2 RWT Practical Factors Training

A. At a minimum, the following topics shall be discussed as part of Practical Factors training:

- Proper PPE donning and doffing procedures
- Use of RWP
- Recognition of postings
- Utilization of ALARA concepts (time, distance, shielding)
- Use of frisking equipment and proper frisking techniques

B. Develop a mock-up area from which trainees may be evaluated. Include the following:

- RWP
- Radiological postings
- Ropes / barriers
- Radiological hazards
- Whole body frisking instrument
- In-use work areas may be used, with RSO approval, and provided that airborne generating activities are not underway.

C. Introduce the practical training by relating it back to the academics the trainees have just completed.

D. Explain what will be expected of each trainee.

E. Demonstrate how to perform the tasks, talk about good practices while doing so.

F. Allow the participants to practice as you coach.

G. Proceed to the Mock-Up area and begin Practical Factors evaluation.

H. Complete a Practical Factors Evaluation Form.

I. Review evaluation results with the trainee and forward form to RP Document Control.

11.0 ATTACHMENTS

None

PERMA-FIX ENVIRONMENTAL SERVICES

TITLE:	**RADIOLOGICAL PROTECTIVE CLOTHING SELECTION, MONITORING, AND DECONTAMINATION**	**NO.:**	RP-132
		PAGE:	1 of 9
		DATE:	March 2017

APPROVED:

Technical Services Manager — 03/10/17 Date

Corporate Certified Health Physicist — 0310/17 Date

1.0 PURPOSE

This procedure provides the guidance for selecting protective clothing, performing personnel surveys, and decontaminating personnel.

2.0 APPLICABILITY

This procedure will be used by Tetra Tech EC, Inc. (TtEC) personnel and its subcontractors while performing activities in areas with known or suspected radioactive contamination.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 “Radiation.”
2. Title 22, California Code of Regulations, Division 4.5; Environmental Health Standards for the Management of Hazardous Waste
3. California Executive Order D-62-02 regarding disposal of decommissioned materials.
4. 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests

8. USNRC IE Information Notice No. 80-22, "Breakdowns in Contamination Control Programs."
9. ANSI N13.2-1969, "USA Standard Guide for Administrative Practices in Radiation Monitoring (A Guide for Management)."
10. RP -102, “Radiological Posting Requirements.”
11. RP -103, “Radiation Work Permits."

4.0 GENERAL

4.1 Discussion

Radioactive material controls are established to provide positive control of radioactive material, prevent inadvertent release of radioactive material to uncontrolled areas, ensure personnel are not unknowingly exposed to radiation from lost or misplaced radioactive material, and to minimize the amount of radioactive waste material generated during PESI activities.

4.2 Definitions

Contamination Area (CA): Means any area with loose surface contamination values in excess of the applicable values specified in RP-104 Acceptable Surface Contamination Levels that is accessible to personnel, or any additional area specified by the RSO. The Contamination Area posting is defined as more restrictive than Radioactive Material Areas, hence all Contamination Area postings are considered to be Radioactive Material postings.

Minimum Detectable Activity (MDA): The smallest amount or concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. MDA depends upon the type of instrument, the counting geometry, and the radionuclide to be detected. MDA has the same meaning as Lower Limit of Detection (LLD). (ANSI N13.3, 1989).

Radioactive Material: Material activated or contaminated by the operation or remediation of the site and by-product material procured and used to support the operation or remediation.

Radioactive Material Area: Any area or room where quantities of radioactive materials in excess of ten times the 10 CFR 20 Appendix C quantities are used or stored, or any area designated a RMA by the RSO which does not exceed the site Contamination Area criteria.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

The RSO is responsible for:

- Identifying the radiological personal protective equipment (PPE) and, when appropriate, ensuring that the radioactive work permit lists the proper radiological PPE.

- Providing guidance and direction for decontamination of personnel.

- Notifying the corporate RSO of any personnel contamination event.

- Reviewing the Personnel Contamination Report and verifying all information is accurate.

- Requesting support from the qualified medical personnel regarding management of personnel who have been exposed to radiological contamination, when appropriate.

- Determining reimbursements and disposition of personal property that cannot be decontaminated.

5.3 Radiation Protection Technicians (RPTs)

The RPT is responsible for:

- Ensuring that workers don and doff the correct PPE properly, and performing decontamination of personnel under the guidance and direction of the RSO.
- Performing and documenting radiation and contamination surveys.
- Posting, securing, and controlling radioactive material and source storage areas.

5.4 Project Personnel

Project personnel are responsible for:

- Adhering to all policies, procedures and other instructions, verbal and written, regarding control and minimization of radioactive material and contaminated material.
- Reporting any concerns about the control and minimization of radioactive material and contaminated material to supervision.
- Maintaining good housekeeping at work sites and assisting in preventing the build-up and spread of contamination.
- Complying with direction from RP personnel regarding the proper methods for donning and doffing of PPE.

6.0 PREREQUISITES

None

7.0 PRECAUTIONS AND LIMITATIONS

PPE should be fully inspected prior to use.

8.0 RECORDS

- Personnel Contamination Reports
- Radiological surveys

Records generated shall be transmitted to Project Document Control for filing according to procedure RPP-114.

9.0 PROCEDURE

The following factors should be considered when selecting PPE:

- The levels and types of radiological material present, or expected, in the work area
- The presence of chemical hazards
- The base in which the contamination is carried (dry, wet, oily)
- The work to be performed, or work in progress

  The location of the contamination (e.g., floor, walls, overhead, air handling systems, sewer systems)
- The physical configuration of the work area
- The environmental conditions, such as heat and humidity
- The exposure situation (vapor, pressured splash, liquid splash, intermittent liquid contact, and continuous liquid contact)
- The toxicity of the radioactive materials and/or chemical(s) (i.e., ability to permeate the skin, and systemic toxicity)
- The physical properties of the contaminant (vapor pressure, molecular weight, and polarity)
- The functional requirements of the task (dexterity, thermal protection, fire protection, and mechanical durability requirements)

Table 9-1 provides guidance for the selection of PPE when radiological hazards are present or suspected.

TABLE 9-1

GUIDE FOR THE SELECTION OF RADIOLOGICAL PROTECTIVE CLOTHING

Removable Contamination Levels	Clothing for Access Only No Work *	Clothing for Work or Access During Work *
General contamination levels < 1,000 dpm/100 cm^2	Level D PPE	Level D PPE
General contamination levels > 1,000 dpm/100 cm^2, but ≤ 10,000 dpm/100 cm^2	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Rubber shoe covers**
General contamination levels > 10,000 dpm/ 100 cm^2, but ≤ 100,000 dpm/100 cm^2	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (or hood) Rubber shoe covers**	Glove liners Gloves Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**
General contamination levels > 100,000 dpm/100 cm^2 See Note ***	Glove liners Gloves (2 pairs) Booties, cloth or PVC Tyvek Cap (optional) Hood Rubber shoe covers**	Glove liners Gloves (2 pairs) Booties (2 pairs), cloth or PVC Tyvek (2 pairs) Cap Hood Rubber shoe covers**

The guidelines for PPE selection specified in Table 9-1 may be modified under certain circumstances, such as the following:

- Wet areas – Where splashing water or spray is present, use rain suits in addition to the protective clothing listed in Table 9-1. A second set of coveralls may not be necessary when a rain suit is worn.
- Standing water – In addition to the clothing requirements for wet areas, use hip boots or waders for deep standing water areas.
- Face shields – Consider for use when there is significant beta radiation, or a likelihood of water splashing and respirators are not required.
- High temperature areas – Consult with the RSO and Site Health and Safety Specialist (SHSS) prior to working in high temperature areas.

9.1 DONNING PROTECTIVE CLOTHING

- Select the appropriate PPE.
- Inspect coveralls, cotton glove liners, gloves, shoe covers, and hoods for rips, tears, and holes, or other indications of damage. If damaged, do not wear the damaged PPE and remove the PPE from service.
- Do not wear PPE that does not fit properly.
- Place dosimetry, if worn, in the upper body area on the interior of the breast tab with the window of the dosimeter facing out. When coveralls that do not have a breast tab or pocket are worn, dosimetry should be attached per the direction of the RSOR or designee. The dosimeter shall not be worn inside clothing or placed in pockets if exposure of bare skin to beta radiation is expected.
- If a respirator is specified in the Radiation Work Permit (RWP), then ensure that he individual using the respirator has been medically cleared for respirator use and is respirator qualified.; and a respirator fit test has been performed.
- Don the respirator.
- Don the hood, if required, allowing it to overlap the rubber around the lens of the face piece and fall over the shoulder.
- If required, tape the hood to the respirator and to the coveralls.
- Ensure that any required hood is slack enough around the shoulders to allow for full head movement.
- Don rubber gloves.
- Tape the innermost pair of rubber gloves to the coverall sleeves.
- Leather work gloves may be substituted for outer rubber gloves on some jobs as specified in the corresponding radiation work permit.
- If specified on the RWP, don additional PPE as required.

9.2 DOFFING OF PROTECTIVE CLOTHING

Before stepping out of the contamination area or airborne radioactivity area to the step-off pad, the worker should:

- Remove exposed tape and place it in the appropriate container.
- Remove rubber overshoes and place them in the appropriate container.
- Remove the outer pair of gloves and place them in the appropriate container.
- Remove the hood, from front to rear, and place it in the appropriate container.
- Remove coveralls, inside out, touching the inside only and place them in the appropriate container.
- Remove the respirator, as applicable, by bending forward at the waist slightly, pulling the respirator away from the face, and then rolling the straps/headbands to remove the respirator, and place it in the appropriate container.
- Take down the barrier closure, as applicable.
- Remove any tape or fastener from the inner shoe cover and place it in the appropriate container.
- Remove a shoe cover and place it in the appropriate container while simultaneously stepping onto the clean step-off pad with the shoe whose shoe cover was just removed. Repeat this process with the other shoe.
- Remove the cloth glove liners and place them in the appropriate container.
- Replace the barrier closure, as applicable.
- Have the Radiological Control Technician (RCT) commence whole body frisking.
- Monitor the dosimeter.

The sequence for the removal of primary and supplemental dosimetry is dependent upon where the dosimetry was worn and the potential for contamination. The sequence for removal of respiratory protection devices may be altered if it is determined that the potential for inhalation of airborne contamination or the spread of surface contamination is reduced by keeping respiratory protection devices on until all protective garments have been removed.

The sequence for protective clothing removal may vary from that described above, under the following circumstances:

- At the discretion of the RCT providing job coverage.
- As designated in the assigned RWP.
- Depending on radiological and hazardous material conditions encountered during the work evolution.

It is important to be aware that pushing clothing or trash into an already full collection container to compress the contents is forbidden as the act can result in the potential for airborne radioactivity.

9.3 MONITORING

During exit surveys, the following procedures should be followed.

- Use the portable instrument staged for the area of concern, which should have both a visual and an audible response.

- Ensure that the instrument is set on slow response, if available, and operating with an audible response.
- Verify that the instrument is operational on the lowest scale and that the area background count rate is acceptable.
- Hold the detector with the window approximately 1/4 inch from the surface being monitored.
- Move the detector over the surface being monitored at a rate not to exceed 2 inches per second. It should take at least 3 minutes to perform a whole body frisk.
- If an increase in the audible response is noted, then cease moving the detector and allow the meter 5 to 10 seconds to stabilize.
- Pause (approximately 5 seconds) at the nose and mouth area to check for indications of inhalation/ingestion of radioactive material.
- Pay particular attention to hands, feet (shoes), elbows, knees, or other areas with a high potential for contamination.
- If no contamination can be detected, as indicated by an alarm or by an audible or visual response distinguishable from background, then exit the area.
- If an audible or visual response distinguishable from background is noted, then the RCT will further investigate to verify if contamination is present.
- If personnel are found to be contaminated, proceed to the procedures outlined in Section 9.3.1.

9.3.1 CONTAMINATED PERSONNEL

When dealing with contaminated personnel, the following procedures should be followed.

1. Notify the RSOR of any individual with known or suspected contamination.
2. If the contamination is on a personal article of clothing, then perform the following:
   - Survey the inside surface that was against the skin.
   - Verify that no contamination was transferred to the skin.

3 .If the contamination is on the skin, determine if the contamination is in the form of a hot particle.

4 If the contamination is a hot particle, then:

- Quickly evaluate the particle size, radiation type, and visible characteristics.
- Attempt to collect and retain the particle for subsequent evaluation.
- Decontaminate the individual in accordance with Section 9.3.2.

5. If the contamination is not a particle, then:
   - Evaluate the contamination levels.
   - Decontaminate the individual in accordance with Section 9.

6. Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

9.3.2 PERSONNEL DECONTAMINATION

The steps to follow for personnel decontamination are presented below.

1. Perform personnel decontamination in a manner that prevents the spread of contamination to other body parts, or the ingestion or inhalation of radioactive material.
2. Take appropriate precautions to minimize the spread of contamination when proceeding from the control point or step-off pad to the decontamination area.
3. Refrain from releasing personnel if detectable skin contamination is present, unless authorized by the RSOR.
4. Perform skin decontamination as follows:
    - Exercise care to avoid damaging the skin.
    - Discontinue the decontamination and notify the RSOR if skin irritation becomes apparent.
    - Record results after each decontamination attempt.
    - indicate the method of decontamination used.
    - Decontaminate ears, eyes and mouth using damp swabs, water, or saline solution rinses that are performed by the individual. Perform further decontamination under the direction of qualified medical personnel.
    - Decontaminate nasal passages by having the individual repeatedly blow the nose. Perform supplemental nasal irrigations under the direction of qualified medical personnel, as required.
    - Use decontamination processes or materials other than those listed in Table 9-2, only under the specific direction of qualified medical personnel.
    - Report incidents of individual contamination immediately to the RSOR.
    - Note the final survey results and time of the survey.
    - Record the area of the skin contaminated in square centimeters (cm^2) on the Personnel Contamination Report (Attachment 1).
    - Assume the measured activity is distributed over the probe area (the area of a typical pancake probe is 15.5 cm^2) for contamination distributed over an area greater than or equal to the area of the probe.
    - Determine the actual area of the activity if the area of contamination is less than the area of the probe but greater than 1 cm^2,
    - Assume an area of 1 cm^2 if the contamination area is less than or equal to 1 cm^2.
    - Obtain the information needed to complete the Personnel Contamination Report (Attachment 1) when skin decontamination has been successfully completed.
    - Complete the applicable parts of the Personnel Contamination Report (Attachment 1).

Table 9-2 Decontamination Techniques

TABLE 4-2 PERSONNEL DECONTAMINATION METHODS METHOD	**EFFECTIVE FOR**	**INSTRUCTIONS**
Masking Tape	Dry contamination, hot particles	Apply tape to skin by lightly patting. Remove carefully.
Waterless Hand Cleaner	All skin contamination	Apply to affected area and allow it to melt onto the skin. Remove with cotton or soft disposable towel.
Soap and Tepid Water	All skin contamination except tritium	Wash area with soap and lukewarm water. Repeat until further attempts do not reduce the level. A cloth or surgical hand brush may be used with moderate pressure.
Soap and Cool Water	Tritium contamination	Wash area with soap and cool water. Repeat until further attempts do not reduce the level. A cloth may be used with moderate pressure.
Carbonated Water	All skin contamination	Apply to affected area with cotton or soft disposable towel and wipe with dry towel.
Cornmeal Detergent Paste	All skin contamination	Mix cornmeal and powder detergent in equal parts with enough water to form a paste. Rub onto affected area for 5 minutes. Remove with cotton or disposable towel

Attachment 1
Personnel Contamination Event Report (Front)

Name:______________________ Site Badge#.:__________________ RWP No.:__________________

Employer:________________ Date:_______ Time:_______ Location of Incident:____________________

Description of Work Being Performed:____

Description of Circumstances and the Suspected Cause: ____
____
______

Skin Contamination Survey Summary

Body Location *	Initial Levels dpm/100cm^2	1st Decon Method	Attempt Results dpm/100 cm^2	2ND Decon Method	Attempt Results dpm/100 cm^2	3rd Decon Method	Attempt Results dpm/100 cm^2
A							
B							
C							
D							

* Indicate location on back of form

Nasal Swab Activity: Swab 1______________ dpm/100 cm^2 Swab 2______________ dpm/100 cm^2

Clothing Contamination Survey Summary

Item	Initial Levels dpm/100 cm^2	Decon Method	Final Results dpm/100 cm^2	Released to employee (Y/N)

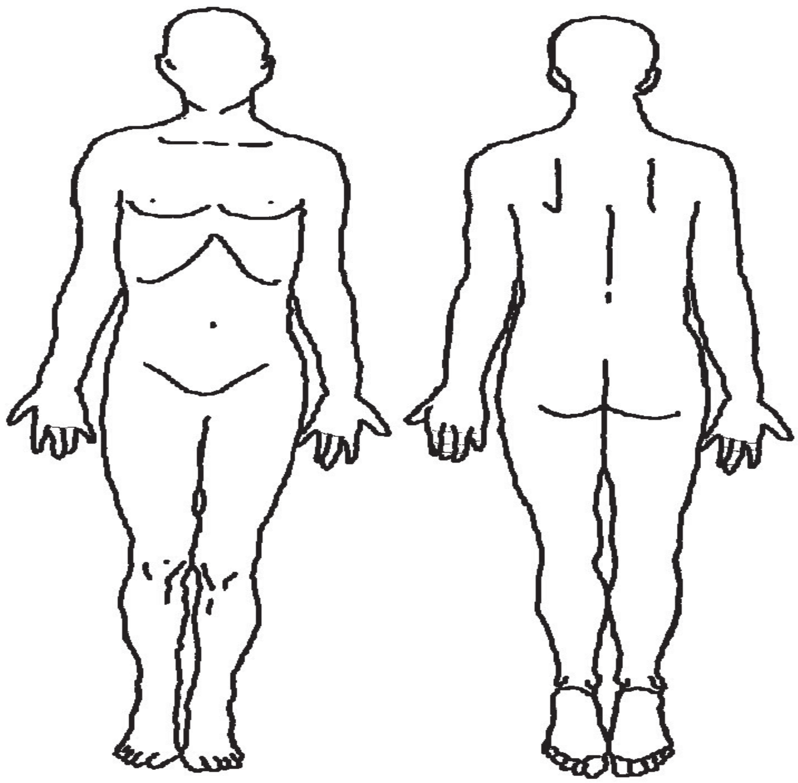
Bioassay Skin Dose ROR Follow-up Potential for Intake?
[ ]Scheduled / [ ] N/A [ ] Calculated / [ ] NA [ ] Initiated / [ ] NA [ ] Yes / [ ] N

_________________ ______________________ ______________________ ______________

SRSO Date RP Technician Date

Attachment 1 (Back of Form)
Personnel Contamination Event Report

Comments and additional detail (identify by letter and include estimated area in square cm):



RP SURVEY INSTRUMENT(S) INFORMATION

Instrument Model	Serial Number	Cal. Due Date

Attachment 3
Laboratory SOPs

NOTIFICATION: THESE PAGES CONTAIN SENSITIVE BUT UNCLASSIFIED INFORMATION WHICH IS PROTECTED BY THE FREEDOM OF INFORMATION ACT

FOIA Exemption 4 (5 USC 552(b)(4))
Privileged/Confidential Trade Secrets, Commercial, Financial Information

Pages 660 to 854

YOU MAY APPEAL THIS DECISION

Based on the redaction, this constitutes a partial denial of your request. Because your request has been denied in part, you are advised of your right to appeal this determination in writing.

Please refer to the accompanying correspondence from the FOIA Office for directions and information about the appeal process.

Attachment 4
Laboratory Certifications

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

GEL LABORATORIES, LLC
2040 Savage Road
Charleston, SC 29414
Robert L. Pullano Phone: (843) 556-8171
rlp@gel.com

ENVIRONMENTAL

Valid To: June 30, 2019 Certificate Number: 2567.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.1 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform the following radiochemical tests in various matrices, including soils, drinking water, wastewater, groundwater, fiber air filters, vegetation, animal tissues, milk and construction debris:

Test(s)	Preparation SOP(s)	Analytical SOP(s)
Alpha Spectrometry: Alpha: Am-241, Am-243, Cf-252, Cm-242, Cm-243/244, Cm-245/246, Np-237, Po-208, Po-209, Po-210, Pu-236, Pu-238, Pu-239/240, Pu-241, Pu-242, Pu-244, Ra-224, Ra-226, Th-228, Th-229, Th-230, Th-232, U-232, U-233/234, U-235/236, U-238	GL-RAD-A-011, GL-RAD-A-016, GL-RAD-A-032, GL-RAD-A-035, GL-RAD-A-036, GL-RAD-A-038, GL-RAD-A-046	GL-RAD-I-009, GL-RAD-I-015
Radon Emanation: Ra-226	GL-RAD-A-008, GL-RAD-A-028	GL-RAD-I-007
Gamma Spectrometry: Gamma: 46 to 1836 keV, I-129, I-131, Ni-59	GL-RAD-A-006, GL-RAD-A-013, GL-RAD-A-022	GL-RAD-I-001
Kinetic Phosphorescence Analyzer: Total Uranium	GL-RAD-A-023	GL-RAD-B-018

Test(s)	Preparation SOP(s)	Analytical SOP(s)
Gas Flow Proportional Counting: Alpha: Total Radium 48 Hour Gross Alpha Gross Alpha/Gross Beta Beta: Cl-36, I-131, Pb-210, Ra-228, Sr-89, Sr-90	 GL-RAD-A-010, GL-RAD-A-044 GL-RAD-A-047 GL-RAD-A-001, GL-RAD-A-001B, GL-RAD-A-001C, GL-RAD-A-001D GL-RAD-A-004, GL-RAD-A-009, GL-RAD-A-017, GL-RAD-A-018, GL-RAD-A-029, GL-RAD-A-030, GL-RAD-A-033, GL-RAD-A-054, GL-RAD-A-058	 GL-RAD-I-006, GL-RAD-I-015, GL-RAD-I-016, GL-RAD-I-021
Liquid Scintillation Spectrometry: Gross Alpha/Gross Beta Alpha: Rn-222 Beta: C-14, Ca-45, Fe-55, H-3, Ni-63, P-32, Pm-147, Pu-241, S-35, Se-79, Tc-99 Pyrolysis Preparation C-14, H-3 (Special Matrices)	 GL-RAD-A-056 GL-RAD-A-007 GL-RAD-A-002, GL-RAD-A-003, GL-RAD-A-005, GL-RAD-A-019, GL-RAD-A-020, GL-RAD-A-022, GL-RAD-A-031, GL-RAD-A-035, GL-RAD-A-040, GL-RAD-A-048, GL-RAD-A-049, GL-RAD-A-050, GL-RAD-A-059 GL-RAD-A-067	 GL-RAD-I-004, GL-RAD-I-014, GL-RAD-I-017
ICP-MS: Uranium Isotopes, Tc-99	 GL-RAD-A-005, GL-RAD-A-055	 GL-RAD-B-034

Additionally, In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in version 5.1 of the DoD Quality Systems Manual for Environmental Laboratories), accreditation is granted to this laboratory to perform recognized EPA, Standard Methods for the Examination of Water and Wastewater, ASTM, California and Connecticut test methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies
Atomic Absorption/ICP-AES Spectrometry, ICP/MS, Gas Chromatography, Gas Chromatography/Mass Spectrometry, Gravimetry, High Performance Liquid Chromatography, Ion Chromatography, Methylene Blue Active Substances, Misc.-Electronic Probes (pH, O_2), Oxygen Demand, Hazardous Waste Characteristics Tests, Spectrophotometry (Visible), Spectrophotometry (Automated), IR Spectrometry, Titrimetry, Total Organic Carbon, Total Organic Halide, Turbidity, Liquid Chromatography/Mass Spectrometer/Mass Spectrometer and Various Radiochemistry Techniques

Parameter/Analyte	**Potable Water**	**Aqueous Film Forming Foams (AFFF)**	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Per-and Polyfluoroalkyl Substances (PFAS)				
Fluorotelomer sulfonate 4:2 (4:2 FTS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Fluorotelomer sulfonate 6:2 (6:2 FTS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Fluorotelomer sulfonate 8:2 (8:2 FTS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorobutanesulfonate (PFBS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorobutyric acid (PFBA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15

Parameter/Analyte	Potable Water	Aqueous Film Forming Foams (AFFF)	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Perfluorodecanesulfonate (PFDS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorodecanoic acid (PFDA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorododecanoic acid (PFDoA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoroheptanesulfonate (PFHpS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoroheptanoic acid (PFHpA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorohexanesulfonate (PFHxS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorohexanoic acid (PFHxA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorononane sulfonate (PFNS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15

Parameter/Analyte	Potable Water	Aqueous Film Forming Foams (AFFF)	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Perfluorononanoic acid (PFNA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorooctanesulfonamide (PFOSA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorooctanoic acid (PFOA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoropentanoic acid (PFPeA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorotetradecanoic acid (PFTeDA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluorotridecanoic acid (PFTrDA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoroundecanoic acid (PFUdA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Perfluoropentanesulfonate (PFPeS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15

Parameter/Analyte	Potable Water	Aqueous Film Forming Foams (AFFF)	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Perfluorooctanesulfonic acid (PFOS)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
N-methyl perfluorooctanesulfonamido acetic acid (N-MeFOSAA)	EPA 537	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	EPA 537 Mod, PFAS by LCMSMS Compliant with QSM 5.1 Table B-15
Propanoic acid (PFPrOPrA) – GenX	EPA 537	EPA 537 Mod*	EPA 537 Mod*	------------

**** Non DoD work***

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Metals		
Aluminum	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Antimony	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B[2]
Arsenic	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Barium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Beryllium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Bismuth	EPA 200.8/6020 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Boron	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Cadmium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Calcium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Chromium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Cobalt	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Copper	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Hafnium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Iron	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Lead	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Lithium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Magnesium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Manganese	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Mercury	EPA 245.1/245.2 EPA 7470/7470A EPA 1631E	EPA 7470/7470A EPA 7471A/7471B
Molybdenum	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Nickel	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Phosphorous	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Potassium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Rhenium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Rhodium	EPA 200.8 EPA 6020A/6020B	EPA 6020/6020A/6020B

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Selenium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Silicon[1]	EPA 200.7 EPA 6010B/6010C/6010D	EPA 6010B/6010C/6010D
Silica as SiO2	EPA 200.7 EPA 6010B/6010C/6010D	EPA 6010B/6010C/6010D
Silver	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B[2]
Sodium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Strontium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Sulfur	EPA 200.7 EPA 6010B/6010C/6010D	EPA 6010B/6010C/6010D
Tantalum	EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Thallium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Thorium	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Tin	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B[2]
Titanium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Tungsten	EPA 200.8 EPA 6020/6020A/6020B	EPA 6020/6020A/6020B
Uranium	EPA 200.8 EPA 6020/6020A/6020B ASTM D5174-02/97 DOE U-02	EPA 6020/6020A/6020B DOE U-02
Isotopic Uranium	EPA 200.8 EPA 6020A/6020B	EPA 6020A/6020B
Vanadium	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Zinc	EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B	EPA 6010B/6010C/6010D EPA 6020/6020A/6020B
Zirconium	EPA 200.8 EPA 6020A/6020B	EPA 6020A/6020B
General Chemistry		
Acidity	EPA 305.1 SM 2310B	----------
Adsorbable Organic Halogens (AOX)	EPA 1650	----------

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Alkalinity	EPA 310.1 SM 2320B	----------
Ammenable Cyanide	EPA 9012A/9012B EPA 335.1 SM 4500-CN^- G	EPA 9012A/9012B
Ammonia Nitrogen (and distillation)	EPA 350.1 SM 4500NH_3 B/H	EPA 350.1 Modified
Biochemical Oxygen Demand (BOD)	EPA 405.1 SM 5210 B	----------
Bromide	EPA 300.0 EPA 9056A	EPA 9056A[3]
Carbon Dioxide (Total and Free by calculation)	SM 4500-CO_2 D	----------
Carbonaceous BOD (CBOD)	EPA 405.1 SM 5210B	----------
Chemical Oxygen Demand (COD)	EPA 410.4 SM 5220D	----------
Chloride	EPA 300.0 EPA 9056A	EPA 9056A[3]
Chlorine (residual)	EPA 330.5 SM 4500-Cl G	----------
Chromium VI	EPA 7196A SM 3500-Cr B	EPA 7196A
Color	EPA 110.2 SM 2120B	----------
Corrosivity toward Steel	----------	EPA 1110/1110A
Cyanide	EPA 335.4 EPA 9012A/9012B SM4500-CN^-E/G	EPA 9012A/9012B
Density	----------	ASTM D5057
Extractable Organic Halides (EOX)	----------	EPA 9023
Fluoride	EPA 300.0 EPA 9056A	EPA 9056A[3]
Ignitability	EPA 1020A/1020B	EPA 1020A/1020B
Iodide	EPA 300.0 EPA 9056A	EPA 9056A
Hardness (by calculation/titration)	EPA 130.2 EPA 200.7/200.8 EPA 6010B/6010C/6010D EPA 6020/6020A/6020B SM 2340B/C	EPA 6010B/6010C/6010D EPA 6020A/6020B
Kjeldahl Nitrogen (TKN)	EPA 351.2 SM 4500N_{org} D	EPA 351.2 Modified
MBAS/Surfactants	EPA 425.1 SM 5540C	----------
Nitrate (as N)	EPA 300.0 EPA 9056A SM4500-NO_3-F	EPA 9056A[3]
Nitrate-nitrite (as N)	EPA 300.0, 353.2 EPA 9056A SM 4500 NO_3-F	EPA 9056A[3]

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Nitrite (as N)	EPA 300.0 EPA 9056A	EPA 9056A[3]
Oil & Grease	EPA 1664A	EPA 1664A[2]
Organic Nitrogen	EPA 350.1 EPA 351.2 TKN – Ammonia	----------
Orthophosphate (as P)	EPA 300.0 EPA 9056A	EPA 9056A[3]
Oxygen, Dissolved	SM 4500O G	----------
Paint Filter Liquids Test	----------	EPA 9095B
Perchlorate	EPA 314.0 EPA 6850	EPA 314.0 Modified EPA 6850
pH	EPA 150.1 EPA 9040B/9040C EPA 9041A SM 4500-H^+ B	EPA 9040B/9040C EPA 9045C/9045D
Reactive Cyanide	Sec 7.3.3 SW846	Sec 7.3.3 SW846
Reactive Sulfide	Sec 7.3.4 SW846	Sec 7.3.4 SW846
Residue- Filterable (TDS)	EPA 160.1 SM 2540C	----------
Residue- Nonfilterable (TSS)	EPA 160.2 SM 2540D	----------
Residue- Total	EPA 160.3 SM 2540B	----------
Residue- Total, fixed, and volatile	SM 2540G	----------
Residue- Volatile	EPA 160.4 SM 2540E	----------
Salinity	SM 2520B	----------
Specific conductance	EPA 120.1 EPA 9050A/120.1 SM 2510B	----------
Sulfate	EPA 300.0 EPA 9056A	EPA 9056A[3]
Sulfite	SM 4500-SO_3^{2-} B	----------
Sulfide	EPA 376.2 EPA 9030B EPA 9034 SM 4500 S^{2-}D	EPA 9030B EPA 9034
Total Nitrate-Nitrite	EPA 353.2 SM 4500-NO_3^-F	----------
Total Organic Carbon (TOC)	EPA 9060/9060A SM 5310B/415.1	EPA 9060/9060A[2]
Total Organic Halides (TOX)	EPA 9020B	EPA 9020B[2]
Total Petroleum Hydrocarbons	EPA 1664A	EPA 1664A
Total Phenolics	EPA 420.4 EPA 9066	EPA 9066
Total Phosphorous	EPA 365.4 SM 4500-P H	EPA 365.4 Modified
Turbidity	EPA 180.1 SM 2130B	----------

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Organic Analytes		
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
1,2 Dibromoethane (EDB)	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
1,2,3-Trichloropropane	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
Purgeable Organics (Volatiles)		
1,1,1,2-Tetrachloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,1-Trichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,2,2-Tetrachloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,2-Trichloro-1,2,2-trifluoroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1,2-Trichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1-Dichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1-Dichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,1-Dichloropropene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,2,3-Trichlorobenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,2,3-Trichloropropane	EPA 504.1 EPA 624.1 EPA 8011 EPA 8260B/8260C	EPA 8260B/8260C
1,2,4-Trichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2,4-Trimethylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8060C
1,2-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2-Dichloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
1,2-Dichloropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,3,5-Trimethylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,3-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,3-Dichloropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
1,4-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,4-Dioxane	EPA 522 EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D/	EPA 8260B/8260C EPA 8270C/8270D
1-Chlorohexane	EPA 8260B	EPA 8260B
2,2-Dichloropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Butanone (Methyl Ethyl Ketone)	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
2-Chloroethyl vinyl ether	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Chlorotoluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Hexanone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Nitropropane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
2-Pentanone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
4-Chlorotoluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
4-Isopropyltoluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
4-Methyl-2-pentanone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acetone	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acetonitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acrolein (propanol)	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Acrylonitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Allyl Chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Benzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Benzyl chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bis(2-chloro-1 methyl-ethyl) ether	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Bromobenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromochloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromodichloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromoform	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Bromomethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Carbon disulfide	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Carbon tetrachloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chlorobenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloroethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloroform	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Chloroprene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
cis-1,2-Dichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
cis-1,3-Dichloropropene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
cis-1,4-Dichloro-2-butene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexane	EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexanone	EPA 8260B/8260C	EPA 8260B/8260C
Cyclohexene	EPA 8260B	EPA 8260B
Dibromochloromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Dibromomethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Dichlorodifluoromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Diethyl ether	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Ethyl Acetate	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
Ethyl Benzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Ethyl methacrylate	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Ethyl tert-butyl ether	EPA 8260B	EPA 8260B
Hexachlorobutadiene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Hexane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Iodomethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Isobutyl alcohol	EPA 624.1 EPA 8015B/8015C EPA 8260B/8260C	EPA 8260B/8260C
Isopropyl alcohol	EPA 8260B	EPA 8260B
Isopropylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Isopropyl ether	EPA 8260B	EPA 8260B
m+p-Xylene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methacrylonitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methyl acetate	EPA 8260B/8260C	EPA 8260B/8260C
Methyl methacrylate	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methyl tert-amyl ether (TAME)	EPA 8260B	EPA 8260B
Methyl tert-butyl ether (MTBE)	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Methylcyclohexane	EPA 8260B/8260C	EPA 8260B/8260C
Methylene chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260C
Naphthalene	EPA 624.1 EPA 625.1 EPA 8310 EPA 8260B/8260C EPA 8270C/8270D[4]	EPA 8310 EPA 8260B/8260C EPA 8270C/8270D[4]
n-Butyl alcohol	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
n-Butylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
n-Propylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
o-Xylene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Pentachloroethane	EPA 624.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Propionitrile	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Sec-Butylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Styrene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
tert-Butyl Alcohol	EPA 8260B/8260C	EPA 8260B/8260C
tert-Butylbenzene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Tetrachloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Tetrahydrofuran	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Toluene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
trans-1,2-Dichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
trans-1,3-Dichloropropene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
trans-1,4-Dichloro-2-butene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Trichloroethene	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Trichlorofluoromethane	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Trihalomethanes	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Vinyl acetate	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Vinyl chloride	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Xylenes, total	EPA 624.1 EPA 8260B/8260C	EPA 8260B/8260C
Semivolatile Compounds		
1,2,4,5-Tetrachlorobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1,2,4-Trichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,2-Diphenylhydrazine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
1,3,5-Trinitrobenzene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
1,3-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,3-Dinitrobenzene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
1,4-Dichlorobenzene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,4-Dioxane	EPA 522 EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
1,4-Dinitrobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1,4-Naphthoquinone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1,4-Phenylenediamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
1-Methylnaphthalene	EPA 625.1 EPA 8270C/8270D[4]	EPA 8270C/8270D[4]
1-Naphthylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,2-Dichlorobenzil	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,3,4,6-Tetrachlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,3-Dichloroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4,5-Trichlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4,6-Trichlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dichlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dimethylphenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dinitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2,4-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
2,6-Dichlorophenol	EPA 625.1/8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
2,6-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
2-Acetylaminofluorene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Butoxyethanol	EPA 8270C/8270D	EPA 8270C/8070D
2-Chloronaphthalene	EPA 625.1 EPA 8270C/8270D[4]	EPA 8270C/8270D[4]
2-Chlorophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Ethoxyethanol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Methyl-4,6-Dinitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Methylnaphthalene	EPA 625.1 EPA 8270C/8270D[4]	EPA 8270C/8270D
2-Methylphenol (o-cresol)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Naphthylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Nitroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Nitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
2-Picoline (2-Methylpyridine)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3,3'-Dichlorobenzidine	EPA 625.1 EPA 8270C/8270D[4]	EPA 8270C/8270D
3,3'-Dimethylbenzidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3/4-Methylphenols(m/p cresols)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3-Methylcholanthrene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
3-Nitroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4,4-Dichlorodiphenyl sulfone	EPA 8270C/8270D	EPA 8270C/8270D
4-Aminobiphenyl	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Bromophenyl phenyl ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Chloro-3-methylphenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Chloroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Chlorophenyl phenyl ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Nitroaniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
4-Nitrophenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
5-Nitro-o-toluidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
7,12-Dimethylbenz(a)anthracene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Acenaphthene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Acenaphthylene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Acetophenone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
alpha, alpha-Dimethylphenethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
alpha-Terpineol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Aniline	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Anthracene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Aramite	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Atrazine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzaldehyde	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzo (a) anthracene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Benzo (a) pyrene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Benzo (b) fluoranthene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Benzo (ghi) perylene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Benzo (k) fluoranthene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Benzoic acid	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Benzyl alcohol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Biphenyl	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Bis(2-chloroethoxy) methane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Bis(2-chloroethyl) ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Bis(2-chloro-1 methyl-ethyl) ether	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Bis(2-ethylhexyl) phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Butyl benzyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Caprolactam	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Carbazole	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Chlorobenzilate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Chrysene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
cis-Diallate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Diallate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dibenzo (a,e) pyrene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dibenzo (a,h) anthracene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Dibenzofuran	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Diethyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dimethoate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dimethyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Di-n-butyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Di-n-octyl phthalate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Dinoseb	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Diphenylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Disulfoton	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Ethyl methacrylate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Ethyl methanesulfonate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Famphur	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Fluoranthene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Fluorene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Hexachlorobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hexachlorobutadiene	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Hexachlorocyclopentadiene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hexachloroethane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hexachlorophene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Hydroxymethyl phthalimide	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Indeno (1,2,3-cd) pyrene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Isodrin	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Isophorone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Isosafrole	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Kepone	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methapyrilene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methyl methacrylate	EPA 8270C/8270D	EPA 8270C/8270D
Methyl methanesulfonate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methyl parathion	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Methylene bis(2-chloroaniline)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Naphthalene	EPA 624.1 EPA 625.1 EPA 8310 EPA 8260B/8260C EPA 8270C/8270D[4]	EPA 8310 EPA 8260B/8260C EPA 8270C/8270D[4]
Nitrobenzene	EPA 625.1 EPA 8330A EPA 8270C/8270D	EPA 8330A EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Nitroquinoline-1-oxide	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Decane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodietheylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodimethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodimethylethylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodi-n-butylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosodi-n-propylamine	EPA 625.1 EPA 8270C/8270D[4]	EPA 8270C/8270D
n-Nitrosodiphenylamine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosomorpholine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosopiperidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
n-Nitrosopyrrolidine	EPA 625.1 EPA 8270C/8270D[4]	EPA 8270C/8270D
n-Octadecane	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
o,o,o-Triethyl phosphorothioate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
o-Toluidine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Parathion, ethyl	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
p-Dimethylaminoazobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pentachlorobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pentachloroethane	EPA 624.1 EPA 625.1 EPA 8260B/8260C EPA 8270C/8270D	EPA 8260B/8260C EPA 8270C/8270D
Pentachloronitrobenzene	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pentachlorophenol	EPA 625.1 EPA 8151A EPA 8270C/8270D	EPA 8151A EPA 8270C/8270D
Phenacetin	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Phenanthrene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Phenol	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Phorate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pronamide (Kerb)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pyrene	EPA 625.1 EPA 8310 EPA 8270C/8270D[4]	EPA 8310 EPA 8270C/8270D[4]
Pyridine	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Safrole	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Sulfotepp	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Thionazin (Zinophos)	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
trans-Diallate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Tributyl Phosphate	EPA 625.1 EPA 8270C/8270D	EPA 8270C/8270D
Pesticides & PCBs		
2,4’-DDD	EPA 8081A/8081B	EPA 8081A/8081B
2,4’-DDE	EPA 8081A/8081B	EPA 8081A/8081B
2,4’-DDT	EPA 8081A/8081B	EPA 8081A/8081B
4,4’-DDT	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
4,4’-DDD	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
4,4’-DDE	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Aldrin	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
alpha-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
beta-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Chlordane (N.O.S)	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
cis-Chlordane (alpha-Chlordane)	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
cis-Nonachlor	EPA 8081A/8081B	EPA 8081A/8081B
delta-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Dieldrin	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endonsulfan sulfate	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endosulfan I	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endosulfan II	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Endrin	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endrin aldehyde	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Endrin ketone	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
gamma-BHC	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Heptachlor	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Heptachlor epoxide	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Hexachlorobenzene	EPA 8081A/8081B	EPA 8081A/8081B
Methoxychlor	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
Mirex	EPA 8081A/8081B	EPA 8081A/8081B
Oxychlordane	EPA 8081A/8081B	EPA 8081A/8081B
Toxaphene	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
trans-Chlordane	EPA 608.3 EPA 8081A/8081B	EPA 8081A/8081B
trans-Nonachlor	EPA 8081A/8081B	EPA 8081A/8081B
PCB-1016 (Aroclor)	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1221	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1232	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1242	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1248	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1254	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1260	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1262	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
PCB-1268	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
Total Aroclors	EPA 608.3 EPA 8082/8082A	EPA 8082/8082A
FID Compounds		
1,1,1-Trichloroethane	EPA 8015C/8015D	EPA 8015C/8015D
2-Butanone (Methyl Ethyl Ketone)	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
4-Methyl-2-Pentanone	EPA 8015C/8015D	EPA 8015C/8015D
Acetone	EPA 8015C/8015D	EPA 8015C/8015D
Benzene	EPA 8015C/8015D	EPA 8015C/8015D

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Chloroform	EPA 8015C/8015D	EPA 8015C/8015D
Diesel Range Organics (DRO)	EPA 8015C/8015D	EPA 8015C/8015D
Diethylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Ethanol	EPA 8015C/8015D	EPA 8015C/8015D
Ethyl acetate	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
Ethylbenzene	EPA 8015C/8015D	EPA 8015C/8015D
Ethylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Gas Range Organics (GRO)	EPA 8015C/8015D	EPA 8015C/8015D
Kerosene	EPA 8015C/8015D	EPA 8015C/8015D
Isobutyl alcohol	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
Isopropyl alcohol (2-Propanol)	EPA 8015C/8015D	EPA 8015C/8015D
m, p-Xylenes	EPA 8015C/8015D	EPA 8015C/8015D
Methanol	EPA 8015C/8015D	EPA 8015C/8015D
Methylene chloride	EPA 8015C/8015D	EPA 8015C/8015D
n-Butyl alcohol	EPA 624.1 EPA 8015C/8015D EPA 8260B/8260C	EPA 8015C/8015D EPA 8260B/8260C
o-Xylene	EPA 8015C/8015D	EPA 8015C/8015D
Propylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Toluene	EPA 8015C/8015D	EPA 8015C/8015D
Triethylene glycol	EPA 8015C/8015D	EPA 8015C/8015D
Volatile Petroleum Products	NWTPH-Gx(WDOE)	NWTPH-Gx(WDOE)
Semi-Volatile Petroleum Products	NWTPH-Dx(WDOE)	NWTPH-Dx(WDOE)
C8-C10 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C10-C12 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C12-C16 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C16-C21 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
>C21-C34 Aliphatic, Aromatic EPH	WDOE EPH	WDOE EPH
Alaska GRO	AK-101 (GRO)	AK-101 (GRO)
Alaska DRO	AK-102 (DRO)	AK-102 (DRO)
Alaska RRO	AK-103 (RRO)	AK-103 (RRO)
EPH Aliphatic C9-C18	MADEP EPH	MADEP EPH
EPH Aliphatic C19-C36	MADEP EPH	MADEP EPH
EPH Aromatic C11-C22 Unadjusted	MADEP EPH	MADEP EPH
Nitrosamines, Nitroaromatics	**8330A is by either LC/MS/MS or HPLC 8330B is by LC/MS/MS**	
1,3,5-Trinitrobenzene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
1,3-Dinitrobenzene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
2,4,6-Trinitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
2,4-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
2,6-Dinitrotoluene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
2-Amino-4,6-Dinitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
2-Nitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Nitrosamines, Nitroaromatics	**8330B is by LC/MS/MS. 8330A is by either LC/MS/MS or HPLC**	
3,5-Dinitroaniline	EPA 8330B[5]	EPA 8330B[5]
3-Nitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
4-Amino-2,6-Dinitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
4-Nitrotoluene	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Nitrobenzene	EPA 625.1 EPA 8330A/8330B[5] EPA 8270C/8270D	EPA 8330A/8330B[5] EPA 8270C/8270D
Nitroglycerin	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Pentaerythritoltetranitrate (PETN)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	EPA 8330A/8330B[5]	EPA 8330A/8330B[5]
Dissolved Gases by FID		
Ethane	RSK 175	-------------------
Ethene	RSK 175	-------------------
Methane	RSK 175	-------------------
Herbicides		
2,4-D	EPA 8151A	EPA 8151A
2,4-DB	EPA 8151A	EPA 8151A
Dalapon	EPA 8151A	EPA 8151A
Dicamba	EPA 8151A	EPA 8151A
Dichloroprop	EPA 8151A	EPA 8151A
Dinoseb	EPA 625.1 EPA 8151A EPA 8270C/8270D	EPA 8151A EPA 8270C/8270D
MCPA	EPA 8151A	EPA 8151A
MCPP	EPA 8151A	EPA 8151A
2,4,5-T	EPA 8151A	EPA 8151A
2,4,5-TP (Silvex)	EPA 8151A	EPA 8151A
Pentachlorophenol	EPA 8151A	EPA 8151A
Radiochemistry		
Barium 133	DOE 4.5.2.3	DOE 4.5.2.3
Cesium 134	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Cesium 137	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3

Parameter/Analyte	Nonpotable Water	Solid Hazardous Waste (Liquids and Solids)
Cobalt-60	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Gamma Emitters	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Gross Alpha	EPA 900.0 EPA 9310	EPA 9310
Gross Beta	EPA 900.0 EPA 9310	EPA 9310
Radioactive Iodine	EPA 901.1 EPA 902.0 DOE 4.5.2.3	DOE 4.5.2.3
Radium-226	EPA 903.0/903.1 DOE Ra-04	DOE Ra-04
Radium-228	EPA 904.0 EPA 9320 DOE 4.5.2.3	EPA 9320 DOE 4.5.2.3
Total Alpha Radium	EPA 903.0 EPA 9315	EPA 9315
Radon-222	SM 7500 Rn-B	----------
Strontium-89	EPA 905.0 DOE Sr-01	DOE Sr-01
Strontium-90	EPA 905.0 DOE Sr-02	DOE Sr-02
Thorium	EMSL-LV	EMSL-LV
Tritium	EPA 906.0	EPA 906.0 Modified
Uranium	EPA 200.8 EPA 6020/6020A ASTM D5174-02/97 DOE U-02	EPA 6020/6020A DOE U-02
Zinc-65	EPA 901.1 DOE 4.5.2.3	DOE 4.5.2.3
Preparatory and Clean-up Methods		
Toxicity Characteristic Leaching Procedure (Inorganics, Extractable Organics, Volatile Organics)	EPA 1311	EPA 1311
Synthetic Precipitation Leaching Procedure	EPA 1312	EPA 1312
Waste Extraction Test (W.E.T.)	CCR Ch. 11, Article 5, Appendix II	CCR Ch. 11, Article 5, Appendix II
Anion Preparation	EPA 9056A[3]	EPA 9056A[3]
Cyanide Distillation	EPA 9010B/9010C SM 4500CN^- C	EPA 9010B/9010C[3]
Sulfide Distillation	EPA 9030B	EPA 9030B
Metals Digestion	EPA 200.2 EPA 3005A EPA 3010A	EPA 3050B
Alkaline Digestion for Hex Chromium	----------	EPA 3060A
Bomb Preparation for Solid Waste	----------	EPA 5050
Mercury Preparation	EPA 245.1/245.2 EPA 7470/7470A	EPA 7471A/7471B

Parameter/Analyte	**Nonpotable Water**	**Solid Hazardous Waste (Liquids and Solids)**
Separatory Funnel Liquid-Liquid Extraction	EPA 3510C	----------
Solid Phase Extraction	EPA 3535A	EPA 3535A (Liquid)
Automated Soxhlet Extraction	----------	EPA 3541
Ultrasonic Extraction	----------	EPA 3550C
Waste Dilution	----------	EPA 3580A
Waste Dilution for Volatile Organics	----------	EPA 3585
Purge and Trap for Volatile Organics	EPA 5030A/5030B/5030C	EPA 5035/5035A/5035H/5035L
Alumina Clean-up	----------	EPA 3610B EPA 3611B
Florisil Clean-up	EPA 3620B/3260C	EPA 3620B/3620C
Silica Gel Clean-up	----------	EPA 3630C
Gel Permeation Clean-up	----------	EPA 3640A
Sulfur Clean-up	EPA 3660B	EPA 3660B
Sulfuric Acid/Permanganate Clean-up	EPA 3665A	EPA 3665A

1 – Calculated from silica determination
2 – Applicable only to liquid 'Solid Hazardous Waste', where liquids may include aqueous, non-aqueous, and oily wastes. Solids may include soils, sediments, sludges, tissues, filters and any matrix deemed non-liquid.
3 – The referenced method is modified to include a simple prep for non-aqueous and/or solid matrix samples.
4 – The analytes may be determined by Selective Ion Monitoring (SIM) using either 8270C or 8270D.
5 – 8330B analysis is performed on LC/MS/MS. 8330A may be performed on either LC/MS/MS or HPLC.

Metals on Filters	**Air Filters**
Aluminum	EPA 6010B/6010C/6010D NIOSH 7303
Antimony	EPA 6010B/6010C/6010D NIOSH 7303
Arsenic	EPA 6010B/6010C/6010D NIOSH 7303
Barium	EPA 6010B/6010C/6010D NIOSH 7303
Beryllium	EPA 6010B/6010C/6010D NIOSH 7303
Cadmium	EPA 6010B/6010C/6010D NIOSH 7303
Calcium	EPA 6010B/6010C/6010D NIOSH 7303
Chromium	EPA 6010B/6010C/6010D NIOSH 7303
Cobalt	EPA 6010B/6010C/6010D NIOSH 7303
Copper	EPA 6010B/6010C/6010D NIOSH 7303
Iron	EPA 6010B/6010C/6010D NIOSH 7303
Lead	EPA 6010B/6010C/6010D NIOSH 7303
Magnesium	EPA 6010B/6010C/6010D NIOSH 7303

Metals on Filters	Air Filters
Manganese	EPA 6010B/6010C/6010D NIOSH 7303
Molybdenum	EPA 6010B/6010C/6010D NIOSH 7303
Nickel	EPA 6010B/6010C/6010D NIOSH 7303
Phosphorous	EPA 6010B/6010C/6010D NIOSH 7303
Potassium	EPA 6010B/6010C/6010D NIOSH 7303
Selenium	EPA 6010B/6010C/6010D NIOSH 7303
Sodium	EPA 6010B/6010C/6010D NIOSH 7303
Strontium	EPA 6010B/6010C/6010D NIOSH 7303
Sulfur	EPA 6010B/6010C/6010D NIOSH 7303
Tin	EPA 6010B/6010C/6010D NIOSH 7303
Titanium	EPA 6010B/6010C/6010D NIOSH 7303
Uranium	EPA 6010B/6010C/6010D NIOSH 7303
Vanadium	EPA 6010B/6010C/6010D NIOSH 7303
Zinc	EPA 6010B/6010C/6010D NIOSH 7303

Drinking Water Organics	Drinking Water
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504.1 EPA 524.2
1,2 Dibromoethane (EDB)	EPA 504.1 EPA 524.2
1,2,3-Trichloropropane	EPA 504.1
1,4-Dioxane	EPA 522
1,1,1,2-Tetrachloroethane	EPA 524.2
1,1,1-Trichloroethane	EPA 524.2
1,1,2,2-Tetrachloroethane	EPA 524.2
1,1,2-Trichloroethane	EPA 524.2
1,1-Dichloroethane	EPA 524.2
1,1-Dichloroethene	EPA 524.2
1,1-Dichloropropene	EPA 524.2
1,2,3-Trichlorobenzene	EPA 524.2
1,2,3-Trichloropropane	EPA 524.2
1,2,4-Trichlorobenzene	EPA 524.2
1,2,4-Trimethylbenzene	EPA 524.2
1,2-Dichlorobenzene	EPA 524.2
1,2-Dichloroethane	EPA 524.2
1,2-Dichloropropane	EPA 524.2
1,3,5-Trimethylbenzene	EPA 524.2

Drinking Water Organics	Drinking Water
1,3-Dichlorobenzene	EPA 524.2
1,3-Dichloropropane	EPA 524.2
1,4-Dichlorobenzene	EPA 524.2
2,2-Dichloropropane	EPA 524.2
2-Butanone (Methyl Ethyl Ketone)	EPA 524.2
2-Chlorotoluene	EPA 524.2
2-Hexanone	EPA 524.2
4-Chlorotoluene	EPA 524.2
4-Isopropyltoluene	EPA 524.2
4-Methyl-2-pentanone	EPA 524.2
Acetone	EPA 524.2
Benzene	EPA 524.2
Bromobenzene	EPA 524.2
Bromochloromethane	EPA 524.2
Bromodichloromethane	EPA 524.2
Bromoform	EPA 524.2
Bromomethane	EPA 524.2
Carbon disulfide	EPA 524.2
Carbon tetrachloride	EPA 524.2
Chlorobenzene	EPA 524.2
Chloroethane	EPA 524.2
Chloroform	EPA 524.2
Chloromethane	EPA 524.2
cis-1,2-Dichloroethene	EPA 524.2
cis-1,3-Dichloropropene	EPA 524.2
Dibromochloromethane	EPA 524.2
Dibromomethane	EPA 524.2
Dichlorodifluoromethane	EPA 524.2
Ethyl Benzene	EPA 524.2
Hexachlorobutadiene	EPA 524.2
Iodomethane	EPA 524.2
Isopropylbenzene	EPA 524.2
Methyl tert-butyl ether (MTBE)	EPA 524.2
Methylene chloride	EPA 524.2
m+p-Xylene	EPA 524.2
Naphthalene	EPA 524.2
n-Butylbenzene	EPA 524.2
n-Propylbenzene	EPA 524.2
o-Xylene	EPA 524.2
Sec-Butylbenzene	EPA 524.2
Styrene	EPA 524.2
tert-Butylbenzene	EPA 524.2
Tetrachloroethene	EPA 524.2
Toluene	EPA 524.2
trans-1,2-Dichloroethene	EPA 524.2
trans-1,3-Dichloropropene	EPA 524.2
Trichloroethene	EPA 524.2
Trihalomethanes	EPA 524.2
Vinyl chloride	EPA 524.2
Xylenes, total	EPA 524.2
Bromoacetic acid	EPA 552.2

Drinking Water Organics	Drinking Water
Bromochloroacetic acid	EPA 552.2
Chloroacetic acid	EPA 552.2
Dibromoacetic acid	EPA 552.2
Dichloroacetic acid	EPA 552.2
Trichloroacetic acid	EPA 552.2

Additionally, in recognition of the successful completion of the A2LA evaluation process (including an assessment of the laboratory's compliance with the 2009 TNI Environmental Testing Laboratory Standard Requirements), accreditation is granted to this laboratory to perform the following bioassay analyses on bone, tissue, urine, fecal, and nasal swabs.

Bioassay Analysis(s)	Preparation SOP(s)	Analytical SOP(s)
Alpha Spectrometry: Alpha: Am-241, Cm-242, Cm-243/244, Cm 245/246, Cf-252, Np-237, Po-208, Po-209, Po-210, Pu-236, Pu-238, Pu-239/240, Pu-242, Pu-244, Ra-224, Ra-226, Th-228, Th-229, Th-230, Th-232, U-232, U-233/234, U-235/236, U-238	GL-RAD-B-001, GL-RAD-B-002, GL-RAD-B-003, GL-RAD-B-010, GL-RAD-B-012, GL-RAD-B-013, GL-RAD-B-017, GL-RAD-B-038, GL-RAD-B-040, GL-RAD-B-041 GL-RAD-B-042	GL-RAD-B-009
Liquid Scintillation Spectrometry: C-14, Fe-55, Gross Alpha, H-3, Ni-59, Ni-63, Pu-241, Tc-99	GL-RAD-B-001, GL-RAD-B-008, GL-RAD-B-011, GL-RAD-B-012, GL-RAD-B-013, GL-RAD-B-016, GL-RAD-B-020, GL-RAD-B-023	GL-RAD-I-004, GL-RAD-I-014, GL-RAD-I-017
Gas Flow Proportional Counting: Beta: Sr-90	GL-RAD-B-001	GL-RAD-I-006, GL-RAD-I-015, GL-RAD-I-016
Bioassay Analysis(s)	**Preparation SOP(s)**	**Analytical SOP(s)**
Gross Alpha/Gross Beta	GL-RAD-B-022	GL-RAD-I-006
Kinetic Phosphorescence Analyzer: Total Uranium	GL-RAD-B-019	GL-RAD-B-018
Radon Emanation: Ra-226	GL-RAD-B-002	GL-RAD-I-007
Refractometer: Specific Gravity	GL-RAD-B-027	GL-RAD-B-027
ICP-MS: Uranium Isotopes	GL-RAD-B-035	GL-RAD-B-034

Gamma Spectrometry: Gamma: Ni-59, 46 to 1836 keV	GL-RAD-B-020, GL-RAD-A-013	GL-RAD-I-001

Accredited Laboratory

A2LA has accredited

GEL LABORATORIES, LLC

Charleston, SC

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2009 TNI Environmental Testing Laboratory Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in Version 5.1 of the DoD Quality System Manual for Environmental Laboratories (QSM), accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION
CORPORATE SEAL 1978
DISTRICT OF COLUMBIA
A2LA

Presented this 30th day of August 2017.

President and CEO
For the Accreditation Council
Certificate Number 2567.01
Valid to June 30, 2019
Revised June 26, 2018

For the tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

CH2M-9000-FZ12-0013, JUNE 2019

CALIFORNIA STATE
ENVIRONMENTAL LABORATORY ACCREDITATION PROGRAM
Accredited Fields of Testing

GEL Laboratories, LLC

2040 Savage Road
Charleston, SC 29407
Phone: (843) 556-8171

Certificate No. 2940
Expiration Date 10/31/2019

Primary Accreditation Body

Field of Testing: 106 - Radiochemistry of Drinking Water

106.010	001	Gross Alpha	EPA 900.0	UT
106.010	002	Gross Beta	EPA 900.0	UT
106.030	001	Radioactive Cesium	EPA 901.1	UT
106.030	002	Radioactive Iodine	EPA 901.1	UT
106.030	003	Gamma Emitters	EPA 901.1	UT
106.040	001	Radioactive Iodine	EPA 902.0	UT
106.050	001	Total Alpha Radium	EPA 903.0	UT
106.050	002	Radium-226	EPA 903.0	UT
106.051	001	Radium-226	EPA 903.1	UT
106.060	001	Radium-228	EPA 904.0	UT
106.070	001	Strontium-89, 90	EPA 905.0	UT
106.070	002	Strontium-89	EPA 905.0	UT
106.070	003	Strontium-90	EPA 905.0	UT
106.080	001	Tritium	EPA 906.0	UT
106.092	001	Uranium	EPA 200.8	UT
106.120	001	Gross Alpha	EPA 00-02	UT
106.230	001	Uranium	DOE U-02	UT
106.250	002	Radioactive Iodine	DOE 4.5.2.3	UT
106.250	003	Gamma Emitters	DOE 4.5.2.3	UT
106.480	001	Uranium	ASTM D5174-97	UT
106.610	001	Radon-222	SM7500-Rn	UT

Field of Testing: 108 - Inorganic Chemistry of Wastewater

108.020	001	Conductivity	EPA 120.1	UT
108.090	001	Residue, Volatile	EPA 160.4	UT
108.110	001	Turbidity	EPA 180.1	UT
108.112	001	Boron	EPA 200.7	UT
108.112	002	Calcium	EPA 200.7	UT
108.112	003	Hardness (calculation)	EPA 200.7	UT
108.112	004	Magnesium	EPA 200.7	UT
108.112	005	Potassium	EPA 200.7	UT
108.112	006	Silica, Dissolved	EPA 200.7	UT
108.112	007	Sodium	EPA 200.7	UT
108.113	001	Boron	EPA 200.8	UT

As of 11/5/2018 , this list supersedes all previous lists for this certificate number.
Customers: Please verify the current accreditation standing with the State.

108.113	002	Calcium	EPA 200.8	UT
108.113	003	Magnesium	EPA 200.8	UT
108.120	001	Bromide	EPA 300.0	UT
108.120	002	Chloride	EPA 300.0	UT
108.120	003	Fluoride	EPA 300.0	UT
108.120	008	Sulfate	EPA 300.0	UT
108.120	012	Nitrate (as N)	EPA 300.0	UT
108.120	013	Nitrate-Nitrite (as N)	EPA 300.0	UT
108.120	014	Nitrite (as N)	EPA 300.0	UT
108.120	015	Phosphate, Ortho (as P)	EPA 300.0	UT
108.183	001	Cyanide, Total	EPA 335.4	UT
108.209	001	Ammonia (as N)	EPA 350.1	UT
108.211	002	Kjeldahl Nitrogen, Total (as N)	EPA 351.2	UT
108.232	003	Nitrate-Nitrite (as N)	EPA 353.2	UT
108.266	001	Phosphorus, Total	EPA 365.4	UT
108.323	001	Chemical Oxygen Demand	EPA 410.4	UT
108.362	001	Phenols, Total	EPA 420.4	UT
108.381	001	Oil and Grease	EPA 1664A	UT
108.385	001	Color	SM2120B-2001	UT
108.390	001	Turbidity	SM2130B-2001	UT
108.400	001	Acidity	SM2310B-1997	UT
108.410	001	Alkalinity	SM2320B-1997	UT
108.420	001	Hardness (calculation)	SM2340B-1997	UT
108.421	001	Hardness	SM2340C-1997	UT
108.430	001	Conductivity	SM2510B-1997	UT
108.439	001	Residue, Volatile	SM2540E-1997	UT
108.440	001	Residue, Total	SM2540B-1997	UT
108.441	001	Residue, Filterable TDS	SM2540C-1997	UT
108.442	001	Residue, Non-filterable TSS	SM2540D-1997	UT
108.465	001	Chlorine, Total Residual	SM4500-Cl G-2000	UT
108.470	001	Cyanide, Total	SM4500-CN B or C-1999	UT
108.472	001	Cyanide, Total	SM4500-CN E-1999	UT
108.473	001	Cyanide, amenable	SM4500-CN G-1999	UT
108.490	001	Hydrogen Ion (pH)	SM4500-H+ B-2000	UT
108.513	001	Kjeldahl Nitrogen, Total (as N)	SM4500-Norg D-1997	UT
108.529	002	Nitrite (as N)	SM4500-NO3 F-2000	UT
108.536	001	Oxygen, dissolved	SM4500-O G-2001	UT
108.545	001	Phosphorus, Total	SM4500-P H-1999	UT
108.560	001	Sulfite	SM4500-SO3 B-2000	UT
108.584	001	Sulfide (as S)	SM4500-S D-2000	UT
108.592	001	Biochemical Oxygen Demand	SM5210B-2001	UT
108.592	002	Carbonaceous BOD	SM5210B-2001	UT

108.595	001	Chemical Oxygen Demand	SM5220D-1997	UT
108.596	001	Organic Carbon-Total (TOC)	SM5310B-2000	UT
108.605	001	Surfactants	SM5540 C-2000	UT

Field of Testing: 109 - Toxic Chemical Elements of Wastewater

109.010	001	Aluminum	EPA 200.7	UT
109.010	002	Antimony	EPA 200.7	UT
109.010	003	Arsenic	EPA 200.7	UT
109.010	004	Barium	EPA 200.7	UT
109.010	005	Beryllium	EPA 200.7	UT
109.010	006	Boron	EPA 200.7	UT
109.010	007	Cadmium	EPA 200.7	UT
109.010	009	Chromium	EPA 200.7	UT
109.010	010	Cobalt	EPA 200.7	UT
109.010	011	Copper	EPA 200.7	UT
109.010	012	Iron	EPA 200.7	UT
109.010	013	Lead	EPA 200.7	UT
109.010	015	Manganese	EPA 200.7	UT
109.010	016	Molybdenum	EPA 200.7	UT
109.010	017	Nickel	EPA 200.7	UT
109.010	019	Selenium	EPA 200.7	UT
109.010	021	Silver	EPA 200.7	UT
109.010	023	Thallium	EPA 200.7	UT
109.010	024	Tin	EPA 200.7	UT
109.010	025	Titanium	EPA 200.7	UT
109.010	026	Vanadium	EPA 200.7	UT
109.010	027	Zinc	EPA 200.7	UT
109.020	001	Aluminum	EPA 200.8	UT
109.020	002	Antimony	EPA 200.8	UT
109.020	003	Arsenic	EPA 200.8	UT
109.020	004	Barium	EPA 200.8	UT
109.020	005	Beryllium	EPA 200.8	UT
109.020	006	Cadmium	EPA 200.8	UT
109.020	007	Chromium	EPA 200.8	UT
109.020	008	Cobalt	EPA 200.8	UT
109.020	009	Copper	EPA 200.8	UT
109.020	010	Lead	EPA 200.8	UT
109.020	011	Manganese	EPA 200.8	UT
109.020	012	Molybdenum	EPA 200.8	UT
109.020	013	Nickel	EPA 200.8	UT
109.020	014	Selenium	EPA 200.8	UT
109.020	015	Silver	EPA 200.8	UT
109.020	016	Thallium	EPA 200.8	UT

109.020	017	Vanadium	EPA 200.8	UT
109.020	018	Zinc	EPA 200.8	UT
109.020	021	Iron	EPA 200.8	UT
109.020	022	Tin	EPA 200.8	UT
109.020	023	Titanium	EPA 200.8	UT
109.190	001	Mercury	EPA 245.1	UT
109.191	001	Mercury	EPA 245.2	UT
109.361	001	Mercury	EPA 1631E	UT
109.445	002	Chromium (VI)	SM3500-Cr B-2009	UT

Field of Testing: 110 - Volatile Organic Chemistry of Wastewater

110.040	000	Purgeable Organic Compounds	EPA 624	UT

Field of Testing: 111 - Semi-volatile Organic Chemistry of Wastewater

111.100	000	Base/Neutral & Acid Organics	EPA 625	UT
111.170	000	Organochlorine Pesticides and PCBs	EPA 608	UT

Field of Testing: 112 - Radiochemistry of Wastewater

112.010	001	Gross Alpha	EPA 900.0	UT
112.010	002	Gross Beta	EPA 900.0	UT
112.020	001	Total Alpha Radium	EPA 903.0	UT
112.021	001	Radium-226	EPA 903.1	UT
112.140	001	Cesium	EPA 901.1	UT
112.140	002	Gamma	EPA 901.1	UT
112.160	001	Radium-228	EPA 904.0	UT
112.170	001	Strontium	EPA 905.0	UT
112.180	001	Tritium	EPA 906.0	UT
112.490	001	Cesium	DOE 4.5.2.3	UT
112.490	002	Gamma Emitters	DOE 4.5.2.3	UT
112.500	001	Strontium	DOE Sr-01	FL
112.510	001	Strontium	DOE Sr-02	UT
112.520	001	Uranium	DOE U-02	UT

Field of Testing: 114 - Inorganic Chemistry of Hazardous Waste

114.010	001	Antimony	EPA 6010B	UT
114.010	002	Arsenic	EPA 6010B	UT
114.010	003	Barium	EPA 6010B	UT
114.010	004	Beryllium	EPA 6010B	UT
114.010	005	Cadmium	EPA 6010B	UT
114.010	006	Chromium	EPA 6010B	UT
114.010	007	Cobalt	EPA 6010B	UT
114.010	008	Copper	EPA 6010B	UT
114.010	009	Lead	EPA 6010B	UT
114.010	010	Molybdenum	EPA 6010B	UT
114.010	011	Nickel	EPA 6010B	UT

114.010	012	Selenium	EPA 6010B		UT
114.010	013	Silver	EPA 6010B		UT
114.010	014	Thallium	EPA 6010B		UT
114.010	015	Vanadium	EPA 6010B		UT
114.010	016	Zinc	EPA 6010B		UT
114.020	001	Antimony	EPA 6020		UT
114.020	002	Arsenic	EPA 6020		UT
114.020	003	Barium	EPA 6020		UT
114.020	004	Beryllium	EPA 6020		UT
114.020	005	Cadmium	EPA 6020		UT
114.020	006	Chromium	EPA 6020		UT
114.020	007	Cobalt	EPA 6020		UT
114.020	008	Copper	EPA 6020		UT
114.020	009	Lead	EPA 6020		UT
114.020	010	Molybdenum	EPA 6020		UT
114.020	011	Nickel	EPA 6020		UT
114.020	012	Selenium	EPA 6020		UT
114.020	013	Silver	EPA 6020	Aqueous Only	UT
114.020	014	Thallium	EPA 6020		UT
114.020	015	Vanadium	EPA 6020		UT
114.020	016	Zinc	EPA 6020		UT
114.103	001	Chromium (VI)	EPA 7196A		UT
114.140	001	Mercury	EPA 7470A		UT
114.141	001	Mercury	EPA 7471A		
114.221	001	Cyanide, Total	EPA 9012A		
114.230	001	Sulfides, Total	EPA 9034		UT
114.241	001	Corrosivity - pH Determination	EPA 9045C		
114.250	001	Fluoride	EPA 9056		FL

Field of Testing: 115 - Extraction Test of Hazardous Waste

115.020	001	Toxicity Characteristic Leaching Procedure (TCLP)	EPA 1311 (TCLP)		
115.021	001	TCLP Inorganics	EPA 1311 (TCLP)		
115.022	001	TCLP Extractables	EPA 1311 (TCLP)		
115.023	001	TCLP Volatiles	EPA 1311 (TCLP)		
115.030	001	Waste Extraction Test (WET)	CCR Chapter11, Article 5, Appendix II		
115.040	001	Synthetic Precipitation Leaching Procedure (SPLP)	EPA 1312 (SPLP)		

Field of Testing: 116 - Volatile Organic Chemistry of Hazardous Waste

116.010	000	EDB and DBCP	EPA 8011	Aqueous Only	
116.080	000	Volatile Organic Compounds	EPA 8260B		
116.080	120	Oxygenates	EPA 8260B		

Field of Testing: 117 - Semi-volatile Organic Chemistry of Hazardous Waste

117.110	000	Extractable Organics	EPA 8270C		
117.140	000	Polynuclear Aromatic Hydrocarbons	EPA 8310		

117.170	000	Nitroaromatics and Nitramines	EPA 8330		FL
117.171	000	Nitroaromatics and Nitramines	EPA 8330A		
117.210	000	Organochlorine Pesticides	EPA 8081A		
117.220	000	PCBs	EPA 8082		
117.250	000	Chlorinated Herbicides	EPA 8151A		
Field of Testing: 118 - Radiochemistry of Hazardous Waste					
118.010	001	Gross Alpha	EPA 9310		
118.010	002	Gross Beta	EPA 9310		
118.020	001	Radium, Total	EPA 9315		
118.030	001	Radium-228	EPA 9320		
118.070	001	Thorium	EPA (March, 1979), p33		
118.140	001	Radium-226	EPA Ra-04		
118.200	001	Gamma Emitters	DOE 4.5.2.3		UT
118.271	001	Strontium	DOE Sr-02		UT
118.290	001	Uranium	DOE U-02		UT
Field of Testing: 120 - Physical Properties of Hazardous Waste					
120.020	001	Ignitability	EPA 1020A		
120.030	001	Corrosivity	EPA 1110		FL
120.040	001	Reactive Cyanide	Section 7.3 SW-846		FL
120.050	001	Reactive Sulfide	Section 7.3 SW-846		FL
120.070	001	Corrosivity - pH Determination	EPA 9040B	Aqueous Only	
120.080	001	Corrosivity - pH Determination	EPA 9045C		

Attachment 5
Technical Systems Audit Checklist

Technical Systems Audit Checklist

Project No. ____________________ **Date of Audit** ____________________

Project Manager ____________________ **Auditor** ____________________

Facility Name ____

Location ____

Weather ____

Field Personnel **FTL:** ____________________ **SSHO:** ____________________

Chemist: ____

____

____

____

Description of Field Activities

____

____

____

____

Summary and Recommendations

____

____

____

____

____

____

____

____

____

____

Planning and Preparation

Yes or No

1. Was the field audit announced or unannounced? ☐ ☐
   Comments: ____
   ____

2. Was a QA Project Plan prepared for this activity? ☐ ☐
   Comments: ____
   ____
   ____

3. Was a site Health and Safety Plan prepared for this activity? ☐ ☐
   Comments: ____
   ____
   ____
   ____

4. Were project instructions, work plan, and contractor SOWs distributed to the team? ☐ ☐
   Comments: ____
   ____
   ____

5. Were additional instructions given to project field participants (i.e., changes in project plan)? ☐ ☐
   Comments: ____
   ____
   ____

6. Was there a written list of sampling locations and descriptions? ☐ ☐
   Comments: ____
   ____
   ____

7. Was there a map of sampling locations available to field personnel? ☐ ☐
   Comments: ____
   ____
   ____
   ____

Planning and Preparation (continued)

Yes or No

8. Was equipment list given to equipment coordinator with adequate lead time? ☐ ☐
Comments: ____

____

____

9. Was laboratory given a list of sample containers with adequate lead time? ☐ ☐
Comments: ____

____

____

10. Were analyses scheduled with the laboratory in advance? ☐ ☐
Comments: ____

____

____

11. Was the project team provided with a contact list (names & phone #s)? ☐ ☐
Comments:____

____

12. Are inexperienced or poorly trained staff receiving adequate training and supervision? ☐ ☐
Comments: ____

____

13 Was State “One Call” agency contacted prior to drilling, trenching, or excavation to identify buried utilities? ☐ ☐
If yes, record Ticket No. _____________, date of request ________, and renewal date _________
Comments: ____

____

____

14 Was an underground utility location contractor retained to identify buried utilities? ☐ ☐
Describe means used to track and verify completion of location activities at each sampling station:____________________________

____

____

Planning and Preparation (continued)

		Yes	No
15	Are dig permits required? If yes, record permit number:____________ date of issue _______, and renewal date _________	☐	☐
16	Are hot work permits required? If yes, record permit number ____________, date and time of issue ___________, and expiration date and time ____________	☐	☐

Monitoring Well Installation

		Yes	No
1	Was a daily tail gate safety briefing conducted? If yes, list the items discussed:______________________________ ______________________________ ______________________________	☐	☐
2	Were the wells located properly with respect to potential contaminant plumes? Comments: ______________________________ ______________________________ ______________________________	☐	☐
3	If field conditions mandated selection of a new location, was the new location properly selected?	☐	☐
	If yes, were the reasons for the relocation properly documented?	☐	☐
4	Were the well locations surveyed?	☐	☐
	Were the exact elevations determined as part of the survey?	☐	☐
	Were elevations referenced to a bench mark?	☐	☐
	Were horizontal coordinates established?	☐	☐
5	Describe the drilling techniques used. ______________________________ ______________________________ ______________________________		
6	Was all in-ground drilling equipment properly decontaminated before initial use and between drilling locations?	☐	☐

Monitoring Well Installation (continued)

Yes or No

7 Describe decontamination procedures (steam cleaner, pressure washer, type of soap used if any, solvent, etc.)

____

____

____

8 How was this equipment stored or otherwise protected after decontamination to prevent recontamination prior to use?

____

____

____

9 What types of casing/screen material were used (black iron, stainless steel, PVC, etc.)?

____

____

____

10 Were well casings/screens properly decontaminated before use? ☐ ☐
Describe decontamination procedure.

____

____

____

11 How was this equipment stored or otherwise protected after decontamination to prevent recontamination prior to use?

____

____

____

12 Were the wells completed to the proper depth? ☐ ☐
Were the wells screened at the proper interval? ☐ ☐
Comments: ____

____

____

13 Were the newly installed wells properly secured (sealed) during the overnight grout curing required before installation of protective outer casing? ☐ ☐

Monitoring Well Installation (continued)

Yes or No

14 Was a locking cap or some other locking mechanism included as part of the protective outer casing? ☐ ☐

15 Describe disposal/storage method used for drilling mud and cuttings.

16 Were samples of drilling mud, sand pack, gravel, grout, etc., collected for analysis? ☐ ☐
Comments:

17 Were the wells developed? ☐ ☐
If yes, describe method used

18 Did the drilling personnel follow required safety protocols? ☐ ☐
Comments:

Sampling

General Procedures

Yes or No

1. Were sampling locations properly selected? ☐ ☐
Comments:

General Procedures (continued)

Yes or No

2. Were samples collected starting with the least likely contaminated and proceeding to the most likely contaminated? ☐ ☐
   Comments: ______________________________

3. Were new disposable gloves worn during sample collection? ☐ ☐
   Comments: ______________________________

4. Was sampling equipment wrapped in aluminum foil or otherwise protected from possible contamination prior to sample collection? ☐ ☐
   Comments: ______________________________

5. If equipment was cleaned in the field, were proper procedures used? (This includes storage method for rinse water and solvents.) ☐ ☐
   Comments: ______________________________

6. What field instruments were used during this investigation?
   ____

7. Were field instruments properly calibrated? ☐ ☐
   Comments: ______________________________

8. Were calibration procedures documented in the field notes? ☐ ☐
   Comments: ______________________________

General Procedures (continued)

Yes or No

9. Were samples chemically field preserved? ☐ ☐
   Comments:

10. Were samples iced? ☐ ☐
   Comments:

11. Were samples of drilling mud, sand pack, gravel, grout, etc., collected for analysis? ☐ ☐
   If yes, please list parameters and procedures.

Groundwater Sampling

Yes or No

1. Was depth of well determined? ☐ ☐
   Comments:

2. Was depth to water determined? ☐ ☐
   Comments:

3. Was measuring tape properly decontaminated between wells? ☐ ☐
   Comments:

4. Were the above depths to water converted to water level elevations common to all wells? Describe how the depths were determined. ☐ ☐

Groundwater Sampling (continued)

Yes or No

5. How was the volume of water originally present in each well determined?
   Comments: ____
   ____
   ____

6. Was the volume determined correctly? ☐ ☐

7. How was completeness of purging determined?
   Volume ☐
   Measure ☐
   Time/Flow Rate ☐
   Cond./pH/T ☐

8. Was a sufficient volume purged? ☐ ☐
   ____
   ____
   ____

9. Describe the disposal of purge water.
   ____
   ____
   ____

10. Was a dedicated (in-place) pump utilized? ☐ ☐
    If no, describe the method of purging (bailer - include type and construction material, pump - include type).
    ____
    ____

11. How were the samples collected?
    Bailer ☐ Passive diffusion bag ☐
    Pump ☐ Peristaltic/Bladder/Centrifugal/Other (check one)
    Other ☐

Groundwater Sampling (continued)

Yes or No

12 Construction material of bailer or tubing:
- S.S. ☐
- Teflon ☐
- PVC ☐
- Other ☐

Design of bailer:
- Open top ☐
- Closed top ☐

Comments: ____________________

____

____

13 If a pump was used, describe how it was cleaned before and/or between wells?

____

____

____

14	Were the samples properly transferred from bailer to sample bottles (i.e., was the purgeable sample agitated, etc.)? Comments: ____________________ ____________________ ____________________	☐	☐
15	Was the rope or line allowed to touch the ground?	☐	☐
16	Was the wetted rope or line discarded after use at each well? ____________________	☐	☐

Surface Water Sampling

Yes or No

1. What procedures were used to collect surface water?

____

____

2.	Did the samplers wade in the stream during sample collection?	☐	☐
	If yes, did sampler face upstream while collecting sample?	☐	☐

Surface Water Sampling (continued)

Yes or No

3 Did the sampler insure that disturbed sediments were not collected along with water sample? ☐ ☐

4 Note any deficiencies observed during the collection of the surface water samples.

____

____

Soil/Sediment Sampling

1. What procedures (including equipment) were used to collect the samples?

____

____

2. Were the samples well mixed prior to placing the sample in the sample container? ☐ ☐

3. Were samples for purgeable organics analysis collected prior to mixing? ☐ ☐

4. Were samples composited? ☐ ☐
If so, how were composites collected and mixed?

____

____

5. Note any deficiencies observed during the collection of the samples.

____

____

Other Sampling

Yes or No

1. What other types of samples were collected during this investigation?

   ____
   ____
   ____

2. What procedures were used for the collection of these samples?

   ____
   ____
   ____

3. Note any deficiencies observed during the collection of these samples.

   ____
   ____
   ____

Quality Assurance/Quality Control

Yes or No

(While not all of these QA/QC procedures will be necessary during each sampling activity, the following techniques may be employed. If so, please note.)

1. Did sampling personnel utilize trip blanks? ☐ ☐

2. Did sampling personnel utilize preservative blanks? ☐ ☐
   If yes, to either of the above questions, list the types and handling of the blanks.
   ____
   ____

3. Were any equipment blanks collected? ☐ ☐
   If yes, list.
   ____
   ____

4. Was the water for field blank preparation appropriate for the parameter coverage? ☐ ☐
   Comments: ______________________________
   ____

5. Were any duplicate samples collected? ☐ ☐
   If yes, list the types (parameter coverage, etc.) and describe their handling.
   ____
   ____
   ____
   ____
   ____
   ____

6. Were any spiked samples collected? ☐ ☐
   If yes, list the types (parameter coverage, etc.) and describe their handling.
   ____

7. Were the QA/QC samples collected in accordance with the QA Project Plan? ☐ ☐

8. Were staff aware of sample holding times? ☐ ☐

Field Documentation and Chain-of-Custody

Yes or No

1. Were Sample I.D. Tags filled out completely (i.e., station no., location, date, time, analyses, signatures of samplers, type of preservative)? ☐ ☐
   Comments: ______

2. Were Chain-of-Custody Records completed for all samples? ☐ ☐
   Comments: ______

3. Did information on Sample I.D. Tags and Chain-of-Custody Records match? ☐ ☐
   Comments: ______

4. Were samples shipped to the laboratory? ☐ ☐
   If yes, did the Chain-of-Custody Record indicate the method of sample shipment?
   ______

5 Was a Chain-of-Custody Record included with the samples in the shipping container? ☐ ☐
   ______

6 Were samples properly secured to maintain custody after collection? ☐ ☐
   Comments: ______

Field Documentation and Chain-of-Custody (continued)

Yes or No

7 Were sample tags, Chain-of-Custody forms, and field notebook signed by sampling personnel? ☐ ☐

Comments: ____________________

8 Does the field notebook contain adequate information about each sample including the sample I.D. number, date, location, and information necessary to reconstruct the sample? ☐ ☐

Comments: ____________________

9 Were entries to the field notebook made in ink? ☐ ☐

Comments: ____________________

10 Were corrections properly executed with one line through the error in the field notebook? ☐ ☐

Comments: ____________________

11 Was sampling documented with photographs? ☐ ☐

If yes, was a photolog maintained?

12 Were amendments to the project plan documented (on the project plan itself, in a project logbook, elsewhere)? ☐ ☐

Comments: ____________________

Debriefing Following Field Audit

Yes or No

1. Was a debriefing held with project participants after the audit was completed? ☐ ☐
   Comments: ____

   ____

2. Were any recommendations made to project participants during the debriefing? ☐ ☐
   If yes, briefly describe recommendations made.

Appendix C
Soil Reference Background Area Work Plan

Naval Facilities Engineering Command Southwest
BRAC PMO West
San Diego, CA

FINAL

SOIL REFERENCE BACKGROUND AREA WORK PLAN

FORMER HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CA

June 2019

Contents

Tables

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Acronyms and Abbreviations

^{40}K	potassium-40
^{90}Sr	strontium-90
^{137}Cs	cesium-137
^{214}Pb	lead-214
^{226}Ra	radium-226
^{230}Th	thorium-230
^{232}Th	thorium-232
^{234}U	uranium-234
^{235}U	uranium-235
^{238}U	uranium-238
^{239}Pu	plutonium-239
µR/hr	microroentgen(s) per hour
APP	accident prevention plan
ASTM	ASTM International (formerly American Society for Testing and Materials)
bgs	below ground surface
CDPH	California Department of Public Health
CH2M	HILL, Inc.
cpm	counts per minute
cpm/µR/hr	counts per minute per microroentgen per hour
DQO	data quality objective
DTSC	Department of Toxic Substances Control
ft^2	square feet
GIS	geographic information system
GPS	global positioning system
HPNS	Hunters Point Naval Shipyard
IDW	investigation-derived waste
KW	Kruskal-Wallis
m/s	meter(s) per second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCA	multi-channel analyzer
MDCR	minimum detectable count rate
NaI	sodium iodide
NaI(Tl)	thallium-doped sodium iodide

Navy	Department of the Navy
NORM	naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Commission Regulation
pCi/g	picocurie per gram
PPE	personal protective equipment
PRSO	Project Radiation Safety Officer
Q-Q	quantile-quantile
RASO	Radiological Affairs Support Office
RBA	reference background area
RG	remediation goal
ROC	radionuclide of concern
ROICC	Resident Officer in Charge of Construction
RPM	Remedial Project Manager
SAP	sampling and analysis plan
SOP	standard operating procedure
SSHP	site safety and health plan
TCRA	Time-critical Removal Action
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey

SECTION 1

Introduction

This work plan provides the details for the radiological characterization of soil reference background areas (RBAs) at the former Hunters Point Naval Shipyard (HPNS) in San Francisco, California. Four onsite RBAs and one offsite RBA, located at the City of San Francisco's John McLaren (McLaren) Park, have been identified for radiological characterization. The radiological characterization will be conducted in accordance with the general approach and methodologies that are provided in the Parcel G Removal Site Evaluation Work Plan (Parcel G Work Plan) (Navy, 2018), Sampling and Analysis Plan (SAP) (included in the Parcel G Work Plan), and a separate Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP). Specific procedures to ensure data quality and worker safety will be described in the SAP and APP/SSHP.

Radiological surveys and remediation have been conducted at HPNS as part of a basewide Time-critical Removal Action (TCRA). Additional efforts to investigate and, if necessary, remediate radiologically impacted sites in Parcels B, C, D-2, E, G, UC-1, UC-2, and UC-3 are planned. The RBA data will be used to evaluate site investigation data to support a final decision on whether residual radioactivity is found to exceed the remediation goals (RGs). The RBA data will also be compared to site investigation data to determine whether further remediation is necessary.

Purpose and Data Quality Objectives

The reference background area data will be collected during the implementation of this work plan to support a final decision on whether residual radioactivity is found to exceed the RGs at HPNS. The RGs presented in **Section 3** specify that the radium-226 (^{226}Ra) RG be set at 1 picocurie per gram (pCi/g) above the background concentration. Previous site radiological surveys and remediation activities did not estimate a reference background concentration for other radionuclides, such as cesium-137 (^{137}Cs) and strontium-90 (^{90}Sr). Both ^{137}Cs and ^{90}Sr are common nuclear fission products that are present worldwide because of radioactive fallout from weapons testing. This work plan describes methods for obtaining RBA data sets for the radionuclides of concern (ROCs) by establishing the following:

- Descriptive statistics and distributions of background concentrations, in pCi/g, for the ROCs, including ^{137}Cs, ^{226}Ra, and ^{90}Sr
- Descriptive statistics and distributions of background concentrations for the naturally occurring radioactive material (NORM) radionuclides, including those associated with the uranium decay series, thorium decay series, and potassium-40 (^{40}K)

Additionally, the data collection protocols and RBA data sets may be used for site evaluation scenarios listed in the Parcel G Work Plan and other work plans (e.g., NORM evaluations, comparison to background, alternative statistical evaluations, and dose and risk analyses).

The data quality objectives for the RBA investigation are as follows:

- **Step 1-State the Problem**: HPNS was expanded over time using fill materials with a range of concentrations of NORM. Construction and remediation projects over the past 60 years have disturbed the surface soil, making a determination of background concentrations for anthropogenic radionuclides from fallout difficult. Previous HPNS soil background values did not provide ^{226}Ra concentrations representative of all fill materials found at HPNS and did not include other NORM or fallout radionuclides.
- **Step 2-Identify the Objective**: Establish representative background soil data sets for comparison and evaluation of soil data collected from HPNS.
- **Step 3-Identify Inputs to the Objective**: Soil analytical data for ROCs using analytical methods are summarized in **Section 3** and detailed in the SAP, included in the Parcel G Work Plan. Gamma scanning measurements will be performed within the RBAs to confirm the areas are free of elevated gamma levels and are suitable for sampling[1] (**see Section 4.1**).
- **Step 4-Define the Study Boundaries**: RBAs at HPNS in Parcels B, C, D-1, and D-2 (**Figure 3-1**), and in an undisturbed off-base location (**Figure 3-2**) will provide a range of background estimates. In Parcels B, C, D-1, and D-2, surface soil samples will be collected from 0 to 6 inches below ground surface (bgs), and subsurface soil samples will be collected from 1- to 2-foot bgs intervals to a depth of up to 10 feet bgs. At the off-base location, surface soil samples will be collected from 0 to 6 inches bgs, and subsurface soil samples will be collected from the 1- to 2-foot bgs interval.
- **Step 5-Develop Decision Rules**: RBA data sets will be compared and evaluated to provide representative RBA data sets with a description to assist in determining applicability for specific projects at HPNS. The data evaluation process is summarized in the following list and detailed in **Section 4**:

[1] If any RBA is found to have signs of contamination, then an alternate RBA will be proposed to regulatory agencies as a replacement.

  - Identify outliers graphically or statistically using Dixon and Rosner's tests for outliers by comparing the calculated Q values or R values to the critical value, corresponding to a confidence level of 95 percent.
    - If outliers are identified graphically or statistically (Q value or R value is greater than critical value), the outlier will be investigated to attempt to determine whether the outlier is the result of contamination, data quality issues, an environmental issue (e.g., different soil type), or an unidentified issue.
    - If no outliers are identified, the entire data set will be used in its entirety.
  - Determine statistical difference between data sets using the non-parametric Kruskal-Wallis (KW) test by comparing the calculated p-value against 0.05 significance level.
    - If the results of the KW test indicate that two or more data sets are statistically similar (p-value is greater than significance level), those data sets may be combined to form a larger data set representing more of HPNS, such as a larger area, multiple soil depths, or additional soil types.
    - If the results of the KW test indicate that a data set is statistically different from other data sets (p-value is less than significance level), that data set will not be combined with other data sets and will be representative of a specific area, soil depth, or soil type.
  - Evaluate secular equilibrium conditions.

- **Step 6-Specify the Performance Criteria**: A statistical data evaluation will be conducted to identify appropriate soil background data sets and calculate descriptive statistics to facilitate future comparisons with site-specific data. The purposes of the data evaluation are as follows:
  - Identify outliers using Dixon's and Rosner's tests for outliers.
  - Determine statistical differences between soil types using the KW test.
  - Compare soil data sets from surface gamma scan surveys, and surface and subsurface analytical concentrations against different identified soil types and against each RBA per sample depth.
  - Establish one or more representative RBA data sets.

- **Step 7-Develop the Plan for Obtaining Data**: RBAs will be characterized by conducting gamma scan surveys of the accessible surface areas and collecting systematic surface and subsurface soil samples, as follows:
  - In Parcels B, C, D-1, and D-2, surface soil samples will be collected from 0 to 6 inches bgs, and subsurface soil samples will be collected from 1- to 2-foot bgs intervals to a depth of up to 10 feet bgs.
  - At McLaren Park, an offsite location with undisturbed surface soil, surface soil samples will be collected from 0 to 6 inches bgs and subsurface soil samples will be collected from the 1- to 2-foot bgs interval.
  - During soil sampling activities, a professional geologist registered in California will annotate the lithologic characteristics and provide accurate and consistent descriptions of soil characteristics.
  - Soil samples will be analyzed for the applicable ROCs along with NORM radionuclides and fallout radionuclides by accredited offsite laboratories, and the results will be evaluated as described in Steps 5 and 6.

Survey Design and Implementation

3.1 Survey Design

The concentrations of NORM radionuclides and fallout radionuclides in soil at HPNS are variable because of the natural variability of native soil and the variability in erosion and deposition of surface soil and fallout radionuclides. In addition, portions of the site were created with fill materials originating from multiple offsite sources. Much of the fill was obtained by grading the hilltop immediately north of HPNS. The source of fill derived from the hilltop is the Hunters Point Shear Zone, a complex structural mixture of serpentinite, shale, sandstone, chert, and gabbro. Fill soil was also obtained from sediment dredged from San Francisco Bay and imported from local quarries and construction sites. Fill soil was generally placed in layers; however, the layering is not contiguous across the shipyard. Soil lithology in filled areas is not readily known at any given location.

Concentrations of fallout radionuclides are variable in soil at HPNS because of deposition, erosion, and mixing during placement of fill soil. Thus, the concentrations of naturally occurring and fallout radionuclides in soil vary by location and depth. The RBA is designed to capture data that are comparable to survey data collected during site investigations at HPNS and representative of the wide range of background concentrations present at HPNS.

Because of potential spatial variability across HPNS, four distinct onsite RBAs have been identified for characterization. In addition, one undisturbed offsite location was selected for characterization of fallout radionuclides. RBAs are geographical areas from which representative radioactivity measurements are collected for comparison with measurements collected in an impacted area (i.e., a survey unit). RBAs are areas that have been identified as non-impacted and should have physical, geological, chemical, radiological, and biological characteristics similar to those of the impacted area being investigated. The RBA characterization methodology will consist of a combination of radiological gamma surveys and soil sampling to establish the HPNS background conditions. Samples will be collected from independent surface and subsurface soil depth intervals. The analytical soil data from the RBAs will be used to generate background population statistics and establish parameters (e.g., mean, median, standard deviation, range).

3.1.1 Radionuclides of Concern

The ROCs vary across media and parcels at HPNS. Because the intent of this RBA characterization is to address all soil ROCs at HPNS, the various soil ROCs and their respective RGs in Parcels B, C, D-2, E, G, UC-1, UC 2, and UC-3 are presented in **Table 3-1**. RBA samples and measurements will be collected and evaluated to establish representative data sets defining natural background and fallout levels of anthropogenic radionuclides. The analytical methods and the radionuclides being analyzed for will be presented in the SAP and are summarized in **Section 3.1.7**.

Table 3-1. Radionuclides and Remediation Goals for Various Soil Areas at HPNS

Radionuclide	Residential Soil Remediation Goal[a] (pCi/g)
^{137}Cs	0.113
^{239}Pu	2.59
^{226}Ra	1.0
^{90}Sr	0.331
^{232}Th	1.69
$^{235+D}U$	0.195

[a]All RGs will be applied as concentrations above background.

^{232}Th = thorium-232

$^{235+D}U$ = uranium-235+D

^{239}Pu = plutonium-239

3.1.2 Survey Methodology Summary

The RBA characterization will incorporate three survey techniques: gamma spectroscopy scans, surface soil sampling, and subsurface soil sampling. The gamma spectroscopy scan will be performed by surveying the accessible surface areas, following removal of any durable cover (if applicable). Soil sampling will occur at various depths from 0 to 10 feet bgs. The sampling design is representative of the survey unit sampling designs in terms of sample depths, spatial distribution, and number of samples to be collected.

3.1.3 Reference Background Area Locations

As part of the previous HPNS TCRA activities, five areas were used as RBAs for soil and were characterized at different times beginning in 2006. Because of access restrictions, this work plan has been designed to use four of the previously established RBA soil areas with adjustments to the shape and size of the areas. In this work plan, the four historically non-impacted RBAs are identified as the following (shown on **Figure 3-1**):

- RBA-1, located on Parcel B
- RBA-2, located on Parcel C
- RBA-3, located on Parcel D-1
- RBA-4, located on Parcel D-2

These four historical RBAs are still considered non-impacted, representative of much of the soil at HPNS, and suitable for use as RBAs. Justification for selecting the non-impacted RBAs is as follows:

- RBA-1, located in the area behind Building 116 on Parcel B, is considered to contain material like that encountered in nearby soils and has been covered with asphalt since the early 2000s.
- RBA-2, southeast of Lockwood Avenue adjacent to Parcel C, is believed to be unimpacted, has no history of radiological use, and has been covered with asphalt since approximately 2015.
- RBA-3, the area between Building 526 and Berth 29 in Parcel D-1, is considered to contain material like that encountered in nearby soils in the Parcel E survey units and has no history of radiological use. The area has been paved with asphalt since the previous RBA characterization.

- RBA-4, located in the Building 813 parking lot in Parcel D-2, has no history of radiological use, is considered to contain material like that encountered in the Parcel G survey units, and has been paved with asphalt since the previous RBA characterization. The land area in Parcel G was originally part of Parcel D and is adjacent to RBA-4; therefore, RBA-4 is considered representative of Parcel G site conditions.

Following characterization of each RBA, a detailed data evaluation will be performed to confirm its suitability as an appropriate RBA. In addition to the four onsite RBAs, an offsite RBA has been identified for surface soil characterization. The City of San Francisco's McLaren Park is located roughly 2.5 miles west of HPNS. McLaren Park is non-impacted by the Department of the Navy (Navy) radiological activities and contains areas where surface soil has been undisturbed by construction activities since prior to atmospheric nuclear weapons testing. McLaren Park occupies 312 acres and includes a nine-hole golf course, playgrounds, amphitheater, and 350,000-gallon water tank. The land area between John F Shelley Drive and Mansell Street contains undisturbed terrain and has been selected as a potential location for the offsite RBA (RBA-McLaren). The RBA-McLaren is shown on **Figure 3-2**. The exact sample locations within McLaren Park may be adjusted based on consultation with the City of San Francisco. Other locations in the San Francisco Bay Area that have been similarly undisturbed may also be used as potential offsite RBA locations.

Both surface gamma scan surveys and surface soil samples will be collected from RBA-McLaren to provide a surface soil data set representative of undisturbed surface soil areas. Additional sample locations at McLaren Park or additional RBA locations may be added as necessary to characterize different soil types and depositional areas.

3.1.4 Number of Samples

The minimum number of samples to be collected was determined using the Parcel G Work Plan and Nuclear Regulatory Commission (NRC) criteria. The NRC criteria for providing characterization of a complex site, found in United States Nuclear Regulatory Commission Regulation (NUREG)-1505 (Section 13.5, page 13-11, last paragraph, second sentence), states that "four reference areas each with between 10 and 20 samples in each should generally be adequate" (NRC, 1998a). Table 13.5, *Power of the F-test when* $\omega^2=\sigma^2$, in NUREG-1505, shows that 20 samples collected from each of 6 reference area data sets will provide 95 percent confidence that the reference area data sets can be combined if they are similar. In this example, the power of this test is 99 percent, meaning there is a 1 percent probability that the data sets will be incorrectly combined when they are not similar. The proposed RBA survey design includes collecting 25 samples from each of up to 10 reference area data sets, providing a power greater than 99 percent while maintaining 95 percent confidence that the data sets can be combined if they are similar.

The null hypothesis (H_o) is that the mean concentrations for each RBA data set are similar and can be combined. The alternative hypothesis is that the mean concentrations for at least one of the RBA data sets are not similar.

Type I decision error would occur when the data sets are not combined when the means are actually equal. The consequence of a Type I error includes having a smaller number of samples in the RBA data set, resulting in less statistical power for evaluating survey unit data sets, potentially resulting in removing soil that has ROC concentrations below the RGs.

Type II decision error would occur when the data sets are combined when the means are actually different. The consequence of a Type II error would include artificially increasing the variability in the combined RBA data set, thereby decreasing the required number of samples in each survey unit.

The Parcel G Work Plan provides a number for samples calculation and determines that a minimum of 18 samples will be collected in each survey unit and each RBA data set; however, that number will be recalculated following the RBA characterization described in the work plan. In order to satisfy both the NRC criteria and the Parcel G Work Plan, the number of samples in each data set was increased to 25 to ensure that sufficient analytical data will be available. Therefore, 25 surface soil samples and 25 subsurface soil samples will be collected from RBAs 1 through 4 for a total of 100 onsite surface soil samples and 100 onsite subsurface soil samples. Additionally, 25 surface soil samples and 25 subsurface soil samples will be collected from RBA-McLaren. Overall, a minimum of 250 soil samples will be collected, as follows:

- 25 surface and 25 subsurface soil samples from RBA-1, located on Parcel B
- 25 surface and 25 subsurface soil samples from RBA-2, located on Parcel C
- 25 surface and 25 subsurface soil samples from RBA-3, located on Parcel D-1
- 25 surface and 25 subsurface soil samples from RBA-4, located on Parcel D-2
- 25 surface and 25 subsurface soil samples from RBA-McLaren, located offsite

This sampling effort will result in up to 10 RBA data sets of 25 samples each from 5 different RBA locations. Additional data sets may be defined based on soil type or other visual observations of the soil samples.

3.1.5 Sample Locations

To simplify the sampling design, the area of each onsite RBA was modified to establish approximately 2,500-square-foot (ft^2) areas within each of the four historical RBA footprints.

3.1.5.1 RBA-1 through RBA-4

For the surface soil sample locations within RBA-1 through RBA-4, a triangular grid will be used to place 25 systematic sample locations. As illustrated on **Figure 3-3**, surface soil samples will be collected from the top 6 inches of soil material at each location for the surface soil data set. For the purposes of this investigation, onsite surface soil is defined as the uppermost 6-inch interval of soil beneath the asphalt and road base materials installed as part of the durable cover.

Within each 2,500-ft^2 surface area, 5 subsurface sampling locations have been established using 5 of the 25 systematic surface sample locations: 1 at the approximate center of each area, and the other 4 located near each of the 4 corners of the area. Subsurface soil samples will be collected from the five sampling locations. As illustrated on **Figure 3-3**, subsurface soil samples will be collected by drilling to a depth of approximately 10 feet bgs from which five subsurface soil samples will be extracted. The proposed subsurface sample depth intervals are the 1- to 2-foot bgs interval, the 3- to 4-foot bgs interval, the 5- to 6-foot bgs interval, the 7- to 8-foot bgs interval, and the 9- to 10-foot bgs interval. If the geologist determines that lithologic characteristics support modification of the proposed depth increments, additional samples may be collected, or the proposed sample depth may be adjusted to match the lithologic characteristics of the soil column. This is further described in **Section 3.2.5**.

Figures 3-4 through **3-7** show the planned surface and subsurface sample locations from RBAs 1 through 4.

3.1.5.2 RBA-McLaren

The planned area for RBA-McLaren, located offsite and within McLaren Park, is a square area measuring approximately 75 feet by 75 feet. Within the estimated 5,600-ft^2 (520-square-meter) surface area, 25 surface sampling locations have been established using a random start systematic triangular grid pattern. Surface soil samples will be collected as described in **Section 3.2** from the top 6 inches of soil at each location for the surface soil data set. Subsurface soil samples will be collected as described in **Section 3.2**, from the approximately 1- to 2-foot bgs interval at each location for the subsurface soil data set. **Figure 3-8** shows the planned sample locations for RBA-McLaren. Additional samples may be collected from other locations if areas of relatively undisturbed surface soil with varying geological properties are identified during field sampling activities.

3.1.6 Field Instrumentation, Gamma Detectors

Gamma scanning instruments have been selected to provide a high degree of defensibility, based on their capability to measure and quantify gamma radiation and position. Because there are several specific gamma detection platforms that may be used during upcoming work at HPNS, the minimum requirements for a suitable gamma scan survey system are as follows:

- Thallium-doped sodium iodide (NaI[Tl]) or plastic gamma scintillator
- Equipped with spectroscopy
- Automatic data logging
- Real-time positioning (global positioning system [GPS] or equivalent)

During this initial RBA characterization, gamma scan surveys will be performed using one or more of the instruments shown in **Table 3-2** (or other instruments with equivalent detection sensitivity and meeting the minimum requirements listed above).

Table 3-2. Gamma Survey Instruments

Meter Manufacturer and Model	Detector Manufacturer and Model	Detector Type	Use
Ludlum 2221, Osprey MCA	Bicron 3x5x16 / 3SSL-X	3-inch x 5-inch x 16-inch NaI(Tl) detector	Soil gamma scan surveys
Ludlum 2221, MCA	Ludlum Model 44-20	3-inch x 3-inch NaI(Tl) detector	Soil gamma scan surveys, sample screening, soil core surveys

Note: Equivalent alternative instrumentation may be used following approval by the Project Radiation Safety Officer (PRSO) and Field Team Lead.

MCA = multi-channel analyzer

The field survey instrumentation will be calibrated, used, and maintained in accordance with the requirements and standard operating procedures (SOPs) provided in the Parcel G Work Plan and according to the SAP.

3.1.6.1 Instrument Detection Calculations

The equations to calculate efficiencies, minimum detectable concentrations (MDCs), and minimum detectable count rates (MDCRs) at HPNS are based on the methodology and approach used in *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* Chapter 6 (USEPA et al., 2000) and NUREG-1507 Chapter 6 (NRC, 1998b).

3.1.6.2 Gamma Surface Activity

Estimating the amount of radioactivity that can be confidently detected using field instruments is performed by adapting the methodology and approach used in MARSSIM Section 6.7.2.1 (USEPA et al., 2000) and NUREG-1507 Section 6.8.2 (NRC, 1998b) for determining the gamma scan MDC for photon-emitting radionuclides.

The scan MDC (in pCi/g) for areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). The computer code Microshield can be used to model expected exposure rates from the radioactive source at the detector probe sodium iodide (NaI) crystal and includes source-to-detector geometry. The geometry is used to calculate the total flow of photons incident upon the detector crystal, called the gamma fluence rate, ultimately corresponding to an exposure rate that is associated with a count rate in the instrument.

The amount of radiation the detector crystal is exposed to from the modeled source is used to determine the relationship between the detector's net count rate and the net exposure rate (counts per minute per microroentgen per hour [cpm/µR/hr]).

3.1.6.3 Gamma Scan Minimum Detectable Concentration

The minimum detectable number of net source counts in the scan interval is given by s_i, which can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in *d'*), as shown in **Equation 3-1** (Equation 6-8 of MARSSIM):

Equation 3-1

$$s_i = d'\sqrt{b_i}$$

Where:

d' = index of sensitivity (α and β errors [performance criteria])
b_i = number of background counts in scan time interval (count)
i = scan or observation interval (seconds)

For scanning at HPNS, the required rate of true positives will be 95 percent, and the false positives will be 5 percent. From Table 6.5 of MARSSIM, the value of *d'*, representing this performance goal, is 3.28. The MDCR, in counts per minute (cpm), is calculated by **Equation 3-2** (Equation 6-9 of MARSSIM):

Equation 3-2

$$MDCR = s_i \times (60/i)$$

Where:

s_i = minimum detectable number of net source counts in the scan interval
i = scan or observation interval (seconds)

Next, the MDCR is used to calculate the *Surveyor* MDCR by applying a surveyor efficiency factor as follows in **Equation 3-3** (Page 6-45 of MARSSIM):

Equation 3-3

$$MDCR_{Surveyor} = \frac{MDCR}{\sqrt{p}}$$

Where:

MDCR = minimum detectable count rate
p = surveyor efficiency

After a surveyor efficiency is selected, the relationship between the $MDCR_{surveyor}$ and the radionuclide concentration in soil (pCi/g) is determined. This correlation requires two steps: 1) establish the relationship between the detector's net count rate and net exposure rate (cpm/µR/hr), and 2) determine the relationship between the radionuclide contamination and exposure rate. The relationship between the detector's net count rate and net exposure rate may be determined analytically using reference guidance documents, or obtained from the detector manufacturer. Modeling (using Microshield) of the source area is used to determine the net exposure rate produced by a given concentration of a radionuclide at a specific distance above the source. The scan MDC is calculated by **Equation 3-5** (Page 6-45 of MARSSIM):

Equation 3-5

$$ScanMDC = \left(\frac{MDCR_{surveyor}}{\epsilon_{inst}}\right) \times \left(\frac{Radionuclide\ Concentration[pCi/g]}{Exposure\ rate[\mu R/h]}\right)$$

Where:

$MDCR_{surveyor}$ = minimum detectable count rate surveyor
ε_{imst} = instrument efficiency (cpm/µR/hr)
Radionuclide Concentration = modeled source term concentration (pCi/g)
Exposure Rate = result of model (microroentgen(s) per hour [µR/hr])

3.1.6.4 Example Gamma Scan Minimum Detectable Concentrations

An example a priori scan MDC calculation is provided herein for ^{226}Ra using a Ludlum 2221 with a Model 44-20 (3-inch by 3-inch NaI) detector. This example assumes a background level of 18,000 cpm, and 95 percent correct detections and 95 percent false positive rates resulting in a *d'* of 3.28. A scan rate of 0.5 meter per second (m/s) (19.7 inches per second) provides an observation interval of 2 seconds (based on a diameter of approximately 1 meter for the modeled area of elevated activity). The $MDCR_{surveyor}$ was then calculated assuming a surveyor efficiency (ρ) of 1 (assumes automated data logging). The scan MDC is calculated as follows:

$$s_i = 3.28 * \sqrt{\frac{18{,}000 * 2sec}{60sec}} = 80\ counts$$

$$MDCR = 80 * \left(\frac{60\ sec}{2\ sec}\right) = 2{,}410\ cpm$$

$$MDCR_{surveyor} = \frac{2{,}410\ cpm}{\sqrt{1}} = 2{,}410\ cpm$$

The relationship between the detector's net count rate and net exposure rate has been obtained from the detector manufacturer and is 2,300 cpm/µR/hr. The relationship between the radionuclide contamination and exposure rate has been determined by modeling (using Microshield) the source area to determine the net exposure rate produced by a given concentration of a radionuclide at a specific distance above the source. The Microshield Version 11.20 model has a source activity of 1 pCi/g of ^{226}Ra, a circular area of elevated activity of 1 square meter, a contaminated zone depth of 15 centimeters (6 inches), and a soil density of 1.6 grams per cubic centimeter. The modeling code determined an exposure rate at the detector height (dose point) of 10 centimeters (4 inches) above the source to be 1.130 µR/hr. The scan MDC for this source geometry is calculated as follows:

$$ScanMDC = \left(\frac{2{,}410cpm}{2{,}300cpm/\mu R/h}\right) \times \left(\frac{1.0[pCi/g]}{1.130[\mu R/h]}\right) = 0.93\ pCi/g$$

Additional a priori determinations are provided in **Table 3-3**. The Microshield model parameters are identical to those described in the previous example, using either ^{226}Ra with a concentration of 1 pCi/g, or ^{137}Cs with a concentration of 0.113 pCi/g.

Table 3-3. A Priori Scan MDCs

NaI Detector	Remediation Goal	Scan MDC
Ludlum 44-20, 3x3	^{226}Ra, 1.0 pCi/g	0.93 pCi/g
	^{137}Cs, 0.113 pCi/g	2.30 pCi/g
Bicron 3SSL-X, 3x5x16	^{226}Ra, 1.0 pCi/g	0.21 pCi/g
	^{137}Cs, 0.113 pCi/g	0.46 pCi/g

After field mobilization, MDC calculations will be revised using actual site-and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the background report.

3.1.7 Laboratory Analysis

Soil samples will be collected from the RBAs and sent offsite to an analytical laboratory for various analyses. The analytical methods and the radionuclides being analyzed for are presented in the SAP and are summarized in **Table 3-4**. The SAP provides additional guidance on soil sampling, chain-of-custody, laboratory analysis, and quality assurance/quality control requirements.

Table 3-4. Analytical Sample Summary

Analytical Method	Radionuclide
Gamma Spectroscopy (gamma-emitting ROCs and naturally occurring radionuclides)	^{137}Cs ^{226}Ra (equilibrated; via ^{214}Bi and/or ^{214}Pb) ^{238}U Series (^{238}U via protactinium-234m, ^{214}Pb, ^{214}Bi) ^{232}Th Series (^{228}Ac, ^{212}Pb, ^{212}Bi, ^{208}Tl) ^{40}K ^{241}Am
Alpha Spectroscopy (alpha-emitting ROCs and naturally occurring radionuclides)	^{239}Pu /^{240}Pu ^{241}Am ^{226}Ra Thorium (^{232}Th, ^{230}Th, ^{228}Th) Uranium (^{238}U, ^{235}U, ^{234}U)
Radon Emanation (Lucas Cell) (to support future NORM evaluations)	^{226}Ra
Gas Flow Proportional Counting	^{90}Sr

Notes:

^{208}Tl = thallium-208

^{212}Bi = bismuth-212

^{212}Pb = lead-212

^{214}Bi = bismuth-214

^{214}Pb = lead-214

^{228}Ac = actinium-228

^{228}Th = thorium-228

^{230}Th = thorium-230

^{234}U = uranium-234

^{238}U = uranium-238

^{240}Pu = plutonium-240

^{241}Am = americium-241

3.2 Survey Implementation

Prior to initiating the RBA characterization field activities, several premobilization and mobilization steps will be performed to ensure that work can be performed in a safe and efficient manner.

3.2.1 Premobilization Activities

The primary premobilization tasks include training of field personnel, procurement of support services, and obtaining access to onsite and offsite RBAs. Coordination with the City of San Francisco will be conducted to facilitate access and approval for sampling and ground disturbance activities at McLaren Park. Sampling at McLaren Park will only be conducted if access and approval are granted. The various support services that are anticipated to be required are as follows:

- Radiological analytical laboratory services
- Drilling subcontractor
- Civil surveying subcontractor
- Utility location subcontractor
- Vegetation clearance subcontractor

3.2.1.1 Training Requirements

Any non-site-specific training required for field personnel will be performed prior to mobilization to the extent practical. Training requirements are outlined in the Parcel G Work Plan and in SOP RP-115, *Radiation Worker Training*, included in the Parcel G Work Plan.

Medical examinations, medical monitoring, and training will be conducted in accordance with the APP/SSHP and Parcel G Work Plan requirements.

3.2.1.2 Permitting and Notification

Prior to initiation of field activities for the radiological investigation, the contractor will notify the Navy Remedial Project Manager (RPM), Resident Officer in Charge of Construction (ROICC), Radiological Affairs Support Office (RASO), Caretaker Site Office, and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained prior to mobilization.

The contractor will notify the California Department of Public Health at least 14 days prior to initiation of activities involving the Radioactive Material License (**Section 5**).

3.2.1.3 Pre-Construction Meeting

A pre-construction meeting will be held prior to mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles and responsibilities of project personnel, project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will be invited to/attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- Contractor (Project Manager, Site Construction Manager, Project Quality Control Manager, PRSO, and Site Safety and Health Officer)
- Subcontractors as appropriate
- United States Environmental Protection Agency (USEPA), Department of Toxic Substances Control (DTSC), and California Department of Public Health (CDPH)

3.2.2 Site Survey Preparation Activities

The following steps will be implemented to prepare for the sampling activities and to facilitate access to the site:

- Review the applicable activity hazard analyses prior to starting work evolutions.
- Cut brush and weeds (if appropriate) within each RBA to a maximum height of 4 inches to facilitate scanning and sampling activities.

- Locate and mark utilities in the field.
- Verify that utilities have been deactivated (to the extent possible) and if not deactivated, the active utilities will be further identified and marked to ensure that field personnel understand the exact location and estimated depth. An exclusion area will be placed around the active utilities to prevent accidental exposure to the utility, based on the utility hazard or importance.
  - If utilities are in locations that interfere with planned RBA characterization activities, the area may be relocated, as long as the area remains within the historical RBA footprint.
- Remove debris or obstacles that could obstruct sampling and survey activities. Surface obstructions preventing access will be removed prior to direct-push activities.
- Locate and mark the planned sample locations.

3.2.3 Scan Measurements

Following the completion of the site preparation activities, 100 percent of the accessible surface (i.e., ground level surface) of each RBA will be scanned for gamma activity using one or more of the instruments specified in **Table 3-2** (or equivalent). Both gross gamma and gamma spectral measurements will be collected simultaneously during the gamma scan.

The gamma scans of the accessible surface areas will be performed using a GPS coupled with an appropriate gamma scintillation detector or meter (e.g., Ludlum 44-20 or Bicron 3x5x16/3SSL-X). Along with position, each gamma measurement will be coupled with a date and time stamp. The scans will be performed following a NUREG-1575 protocol by scanning straight lines at a rate of approximately 0.5 m/s in approximately 1-meter-wide swaths, with a consistent detector distance from the ground surface (4 inches above the surface) (USEPA et al., 2000). Generally, each RBA will be gamma scanned as follows (the following description assumes that the RBA is positioned such that the sides align with northern, southern, eastern, and western directions):

- Begin with the detector positioned in the southwestern corner of the RBA at a height of about 4 inches above the surface. Orient the system to face north and initiate data collection (detector is automatically logging radiation readings and GPS is automatically logging position readings) so that the system is recording at a rate of one reading per second (or other, as determined by the project health physicist).
- Move the detector in the northern direction at a not-to-exceed speed of 0.5 m/s.
- Once the detector has reached the edge of the RBA, turn the system around (now facing south) and offset the next detector path by approximately 1 meter (or appropriate based on the instrument's detector size) to allow for a small overlap in the detector field of view
- Move the detector in the southern direction at a not-to exceed speed of 0.5 m/s.
- Repeat these steps until the RBA has been scan surveyed.

Assuming a 2,500-ft^2 (232-square-meter) area for each onsite RBA plus 5,600-ft^2 (520-square-meter) area for the offsite RBA (or smaller as appropriate), a survey as described above moving at a speed of 0.5 m/s should result in the collection of a minimum of 1,450 scan measurements over the five RBAs (assuming 100 percent of each RBA is accessible). Offsite RBA locations are assumed to be radiologically non-impacted and in order to be minimally invasive to park areas, gamma scans may be limited to the immediate vicinity of sample locations instead of the whole RBA. Data will be documented and managed as described in **Section 3.2.8**. Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and geographic information system (GIS)-plotted maps. These data sets will be evaluated in accordance with **Section 4**. Following the scan survey, the number of data points and the percent coverage (from a plot of the data) will be reviewed to ensure that the design parameters of the gamma scan survey were satisfied. If elevated scan measurements are observed, follow-up investigations may be performed with static gamma measurements to delineate and characterize potential areas of interest. Areas with elevated scan measurements that are attributed to contamination or discrete radiological objects will not be sampled, and alternate locations will be selected.

3.2.4 Surface Soil Sampling Process at Onsite and Offsite RBAs

Prior to surface sampling, ensure that the necessary gamma scan measurements have been collected as described in **Section 3.2.3** and reviewed and accepted as described in **Section 4.1**. Surface soil samples will be collected in accordance with the *Soil Sampling* SOP, included in the Parcel G Work Plan. Generally, the surface soil samples will be collected as follows:

- For areas without an asphalt cover, a clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil to a depth of 6 inches. For areas with an asphalt cover, sampling will follow the process described in **Section 3.2.5**
- The removed soil will be transferred directly into a clean stainless steel bowl for mixing.
- The soils removed from the sample location will be visually described in the field logbook in accordance with the *Preparing Field Log Books* SOP, included in the Parcel G Work Plan. Identify the sample as surface soil and include the approximate volume of the extracted soil. Color, moisture, texture, and clast composition (i.e., serpentine, shale, sandstone, chert, gabbro) will be identified.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing overburden gravel and biological material. The entire mixed sample, or aliquot thereof, will be placed in the designated laboratory sample container. A minimum of 200 grams of soil (approximately 1 cup) are required to complete all required analyses, or 400 grams if the sample is selected as a field duplicate.
- When a field duplicate sample is required (1 for every 10 field samples collected), the duplicate sample will be collected following mixing of the material and splitting the aliquot into an additional sample container.
- Samples will be identified, labeled, and cataloged according to **Section 3.2.7**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in the Parcel G Work Plan.
- No extra sample material is expected from surface soil sampling because the entire sample will be sent to the laboratory for analysis. Excess soil material that was not sampled will be returned to the hole from which it came or will be spread adjacent to the sample location.
- When possible, disposable sampling equipment will be used because clean, unused materials do not affect sample results. If reusable sampling equipment is used, it will be cleaned between each sampling event as appropriate. Cleaning of sampling equipment will be conducted using SOP RP-112, *Decontamination of Personnel and Equipment*, included in the Parcel G Work Plan.
- If fluids are generated during cleaning of sampling equipment, the fluids will be containerized and sampled for offsite analysis to determine radionuclide concentrations prior to disposal. Other investigation-derived waste (IDW), including used personal protective equipment (PPE) will be radiologically surveyed prior to disposal using SOP RP-105, *Unrestricted Release Requirements*, included in the Parcel G Work Plan.

Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage.

3.2.5 Subsurface Soil Sampling Process at Onsite RBAs

3.2.5.1 Drilling Area Setup

Prior to the commencement of drilling at the sample location (RBAs 1 through 4), the drill site will be prepared by performing the following:

- Clear overhead obstacles, as necessary, to safely operate the drill rig (minimum of 10 feet of clearance between top of drill boom and obstacles).
- Review and ensure that subsurface clearance has been performed and drilling has been approved.
- If utility or other obstacles prevent safe working conditions, the sample location can be re-located at the discretion of the field team lead. To the extent practical, the new sample location should be moved to a safe location as close to the original planned location, while staying within the 400-ft^2 area.

3.2.5.2 Subsurface Soil Sample Collection

Prior to subsurface sampling, ensure that the necessary gamma scan measurements have been collected as described in **Section 3.2.3** and reviewed and accepted as described in **Section 4.1**. Subsurface soil samples will be collected by following the *Soil Sampling* SOP, included in the Parcel G Work Plan. Subsurface soil samples will be collected using drilling-rig-mounted equipment to collect samples with thin-walled tube sampling or split-spoon sampling. Generally, drilling and retrieving the boring using the thin-walled tube method will be as follows:

- If an asphalt cover exists at the sample locations, the asphalt will be removed to facilitate soil sampling. Following completion of sampling, asphalt cores will be replaced and sealed.
- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM International (ASTM) D 1587 standard.
- The sampler is lowered into the hole so that the sample tube's bottom rests on the bottom of the hole. The sampler is advanced by a continuous, relatively rapid downward motion. The sampler is withdrawn from the soil formation as carefully as possible to minimize disturbance of the sample. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch-internal-diameter sampler may be required.
- Upon removal of the tube from the ground, drill cuttings in the upper end of the tube are removed, and the upper and lower ends of the tube are sealed. The soil tube will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the tube is carefully cut open to maintain the material in the tube.

Generally, drilling and retrieving the boring using the split-spoon sampling method will be performed as follows:

- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM D 1586 standard.
- The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven down using a weight ("hammer"). To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch-internal-diameter sampler may be required.

- Upon removal of the soil core from the ground, the soil core will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the sampler is carefully split open to maintain the material in the sampler.

Soil tubes and cores will be processed within the background areas; however, because these surveys are performed in reference areas, all locations inside the reference area (not necessarily within the RBA) should be acceptable. One central processing area may be established for the entire investigation, or separate processing areas may be established for each RBA.

Once the soil tube has been cut open or the core has been split open, soil examination and sample collection will occur as follows:

- The geologist will log the soil boring to provide accurate and consistent descriptions of soil characteristics. Soil boring logs will be maintained according to the *Logging of Soil Borings* SOP, included in the Parcel G Work Plan. The geologist will subdivide the soil boring into the 1-foot increments corresponding to the vertical demarcation in the design. Based on observations of the lithologic characteristics, if there is a visible change in soil types in the vertical column, the geologist may modify the proposed depth increments so that a sample volume is representative of a single soil type. The geologist may also recommend that additional samples be collected to adequately represent the observed soil types.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing gravel. The depth, recovery position, and scan measurement information should be correlated to each sample extracted from the core.
- A minimum of 200 grams of soil (approximately 1 cup) are required to complete the analyses, or 400 grams if the sample is selected as a field duplicate. If sample size requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the original sample location within the core and compositing the sample.
- The entire mixed sample will be placed in the designated laboratory sample container and the range of soil depths included in the sample recorded in the field logbook.
- Samples will be identified, labeled, and cataloged according to **Section 3.2.67**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in the Parcel G Work Plan.
- When a field duplicate sample is required (1 for every 10 field samples collected), the sample will be evenly split following mixing of the material and removal of extraneous material, and each aliquot placed into an appropriately labeled sample container.
- Excess soil material will be returned to the hole from which it came or will be managed in accordance with Section 7 in the Parcel G Work Plan.
- When possible, disposable sampling equipment will be used because clean, unused materials do not affect sample results. If reusable sampling equipment is used, it will be cleaned between each sampling event as appropriate. Cleaning of sampling equipment will be conducted using SOP RP-112, *Decontamination of Personnel and Equipment*, included in the Parcel G Work Plan.
- If fluids are generated during cleaning of sampling equipment, the fluids will be containerized and sampled for offsite analysis to determine radionuclide concentrations prior to disposal. Other IDW, including used PPE, will be radiologically surveyed prior to disposal using SOP RP-105, *Unrestricted Release Requirements*, included in the Parcel G Work Plan.

- Depth intervals that are not identified as samples or sent for analysis will be returned to the borehole or spread on the ground adjacent to the borehole.
- Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage.

3.2.6 Subsurface Soil Sampling Process at Offsite RBA

To minimize the impact of the characterization on the offsite RBA (RBA-McLaren), subsurface samples will be collected from the 1- to 2-foot bgs interval using hand tools. Prior to subsurface sampling, ensure that the necessary gamma scan measurements have been collected as described in **Section 3.2.3**, and reviewed and accepted as described in **Section 4.1**, and that the surface soil sample has been collected from the top 6 inches of soil. Subsurface soil samples will be collected in accordance with the *Soil Sampling* SOP, included in the Parcel G Work Plan. Generally, the subsurface soil sample will be collected as follows:

- A clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil to a depth of 1 foot bgs. The removed soil will be placed adjacent to the sample location.
- A clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil from the 1- to 2-foot bgs depth.
- The removed soil will be transferred directly into a clean stainless steel bowl for mixing.
- The soils removed from the sample location will be visually described in the field logbook in accordance with the *Preparing Field Log Books* SOP, included in the Parcel G Work Plan. Identify the sample as surface soil and include the approximate volume of the extracted soil. Color, moisture, texture, and clast composition (i.e., serpentine, shale, sandstone, chert, gabbro) will be identified.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing overburden gravel and biological material.
- A minimum of 200 grams of soil (approximately 1 cup) are required to complete the analyses, or 400 grams if the sample is selected as a field duplicate. If sample size requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the original sample location within the core and compositing the sample.
- The entire mixed sample, or aliquot thereof, will be placed in the designated laboratory sample container.
- When a field duplicate sample is required (1 for every 10 field samples collected), the duplicate sample will be collected following mixing of the material and splitting the aliquot into an additional sample container.
- Samples will be identified, labeled, and cataloged according to **Section 3.2.6**, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in the Parcel G Work Plan.
- Excess soil material will be returned to the hole from which it came or will be spread adjacent to the sample location.
- When possible, disposable sampling equipment will be used because clean, unused materials do not affect sample results. If reusable sampling equipment is used, it will be cleaned between each

sampling event as appropriate. Cleaning of sampling equipment will be conducted using SOP RP-112, *Decontamination of Personnel and Equipment*, included in the Parcel G Work Plan.

- If fluids are generated during cleaning of sampling equipment, the fluids will be containerized and sampled for offsite analysis to determine radionuclide concentrations prior to disposal. Other IDW, including used PPE, will be radiologically surveyed prior to disposal using SOP RP-105, *Unrestricted Release Requirements*, included in the Parcel G Work Plan.
- Split samples will be available to USEPA and DTSC/CDPH to take for independent analysis either real-time during field activities, from the laboratory during analysis and storage, or after laboratory analysis from on-site storage.

3.2.7 Sample Identification

Each surface and subsurface sample will be uniquely identified at the time of collection by the geologist or radiation technician. Samples will be identified as explained in this section.

Sample identifications will use the following format:

AABBBB-CCDD-EEFF-MMYY

Where: AA = facility (HP for Hunters Point will be used in this work plan).

BBBB = site location (RBAs 1 through 4 = RBA1, RBA2, RBA3, RBA4; RBA-McLaren = RBAM).

CC = sample type (options include SS for surface sample or SB for subsurface sample).

DD = sample location number (within each RBA there will be 01 to 25 sample locations; duplicate locations will be assigned the letter “P” after this number [DDP]).

EEFF = two-digit sample interval in feet bgs (EE feet = top of sample interval and FF feet = bottom of sample interval). EE and FF are whole numbers such that a value of “01” represents “1-foot bgs.” Surface samples (samples collected from the 0.0- to 0.5-foot bgs depth interval) will be designated as 000H; H is for half foot. If the surface sample is collected from a depth other than a half foot, the H designation will still be used; however, a note will be included in the field book to indicate the actual depth sampled.

MMYY = two-digit month (MM) and two-digit year (YY) corresponding to the collection month and year. Example for a sample collected in June of 2018 is MMYY = 0618.

For example, a surface soil sample collected from RBA-1 at sample Location 1 in March 2018 will be identified as follows:

HPRBA1-SS01-000H-0318

In this example, “HPRBA1” identifies Hunters Point Reference Background Area 1. “SS01” identifies the sample as a surface sample collected at sample location 01. “000H” represents the depth interval for a surface sample (000H is the agreed-upon code established for surface samples as explained above).

For example, a subsurface sample collected from RBA-4 at sample Location 5 from the 9- to 10-foot bgs interval in April 2018 will be identified as follows:

HPRBA4-SB05-0910-0418

A duplicate sample collected from the sample location will be identified as follows[2]:

[2] For USEPA and DTSC/CDPH split samples, the sample location number “DD” will be given additional letters.

HPRBA4-SB05P-0910-0418

An example of a surface sample collected from RBA-McLaren at sample Location 12 in June 2018 will be identified as follows:

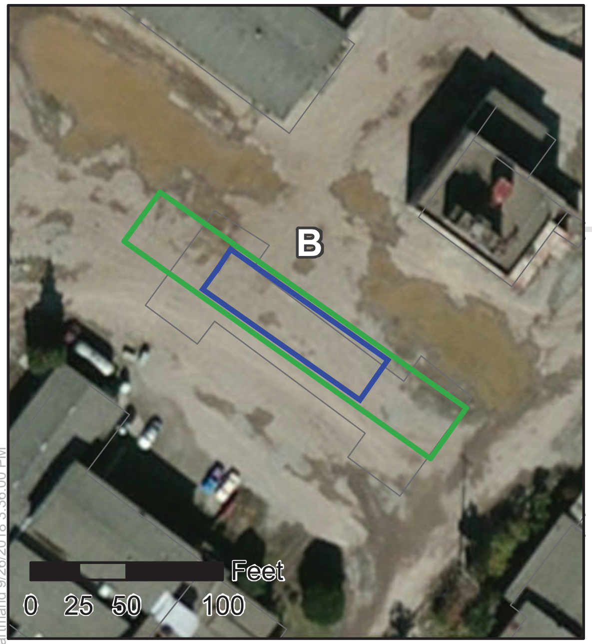
HPRBAM-SB12-000H-0618

3.2.8 Documentation and Sample Shipping

Samples will be documented in accordance with the general requirements in the *Preparing Field Log Books* and the *Chain-of-Custody* SOPs, included in the Parcel G Work Plan. These SOPs identify the requirements for sample labels, custody seals, and chains-of-custody. A digital sample documentation/tracking program may be used during the execution of the work plan to provide additional confidence in sample recordkeeping and to add efficiencies to the process.

Samples will be packaged and shipped for offsite analysis in accordance with the *Packaging and Shipping Procedures for Low-Concentration Samples* SOP, included in the Parcel G Work Plan.

Radiological surveys will be performed and documented in accordance with SOP RP-106, *Survey Documentation and Review*, included in the Parcel G Work Plan. Sample collection, field measurements, and laboratory data will be recorded electronically to the extent practicable. Electronically recorded data and information will be backed up to a SharePoint site or equivalent on a nightly basis, or as reasonably practical. Data and information recorded on paper will be recorded using indelible ink. Both electronic and paper records of field-generated data will be reviewed by the PRSO or a designee knowledgeable in the measurement method for completeness, consistency, and accuracy. Data manually transferred to paper from electronic data collection devices will be compared to the original data sets to ensure consistency and to resolve noted discrepancies. Electronic copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device. No data reduction, filtering, or modification will be performed on the original electronic versions of data sets.



Legend:

- Reference Background Area
- Historical Reference Background Area
- Installation Boundary
- Parcel Boundary
- Current and Former Building Site

N

Feet
0 250 500 1,000

BASE MAP SOURCE:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-1
HPNS Reference Background Areas
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Legend:

- Reference Background Area*
- Park
- Installation Boundary

* NOTE:
The exact location of the RBA within McLaren Park may be adjusted based on consultation with the City of San Francisco.

BASE MAP SOURCE:
Service Layer Credits: © 2018 Microsoft Corporation Earthstar Geographics SIO
© 2018 Microsoft Corporation © 2018 DigitalGlobe ©CNES (2018) Distribution Airbus DS

Park Lands layer developed by the San Francisco Recreation and Parks Department (2016).

Figure 3-2
Offsite Reference Background Area, McLaren Park
Soil Reference Background Area Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California